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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

Review of Scientific Advice for 2011
Part 3b
Advice on Stocks of Interest to the European Community in the Black Sea

11 – 15 OCTOBER 2010 CÁDIZ, SPAIN

Edited by Georgi Daskalov and Hans-Joachim Rätz

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The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

STECF COMMENTS ON THE REPORT OF THE SGRST-10-03 PART B WORKING GROUP ON ADVICE ON STOCKS OF INTEREST TO THE EUROPEAN COMMUNITY IN THE BLACK SEA

11 – 15 Ocotober 2010 Cádiz, SPAIN

STECF UNDERTOOK THE REVIEW DURING THE PLENARY MEETING

HELD IN BRUSSEL 8-12 NOVEMBER 2010

1. BACKGROUND

In accordance with its Terms of Reference (ToR) the work of STECF's subgroup on Black Sea stocks and fisheries continued in 2010 with a dedicated meeting in parallel with the SGRST-10-03 meeting on the review of scientific advice SGRST10-03 part a, which was held during 11-15 October 2010 in Cadiz, Spain. The meeting dates were set to allow all Black Sea fisheries and scientific data being considered including non-EU states. The STECF response is provided as stock summary sheets for sprat and turbut, while the present report of SGRST-10-03 part B also contains data updates and new detailed assessments of relevant stock parameters and management reference points in the format elaborated in 2008 by STECF SGMED.

2. TERMS OF REFERENCE

Without prejudice, STECF is requested to advice in particular on 2011 catch limitations as well as any additional management or technical measure in line with EU policy objectives and principles for sustainable fisheries management for the stocks listed below.
SG-RST 10-03 is requested to address the following ToR for Black Sea stocks:

- compile and provide complete sets of national annual data on landings, discards, landings at age, discards at age, mean weight at age in the landings, mean weight at age in the discards, maturity ogives at age and natural mortality at age by area for the longest time series available up to and including 2009. The data should be compiled based on official data bases, best expert knowledge and by using the results of scientific surveys.
- compile and provide all fishery independent data (pelagic, demersal, hydro-acoustic surveys) for the stocks as available, their juveniles, eggs or early life stages. In order to allow the use of such data to potentially calibrate virtual population analyses, the abundance, biomass and spawning stock biomass indices at age should be compiled for the longest time series available up to and including 2010.

- compile and provide complete sets of annual fishing effort data (number of vessels, kW*days, fished hours) by nation, for fleets and gears (mesh size where applicable), and area for the longest time series available up to and including 2009.
- assess trends in historic stock parameters for the longest time series available up to and including 2010 (fishing mortality at age, spawning stock biomass, stock biomass, recruits at age). Different assessment models should be applied as appropriate, including analyses of retrospective effects.
- review and evaluate existing management measures and suggest additional measures in the short and medium term as well as long term management strategies in accordance with EU policy on fisheries;
- propose and evaluate candidate limit and target reference points consistent with maximum sustainable yield and precautionary approach;
- predict spawning stock biomass, stock biomass, recruits and catches at age and in weight in 2010, 2011 and the beginning of 2012 under different management scenarios including the status quo fishing (mean F at age 2008-2010, rescaled to 2010) and with a TAC constraint for 2010. Specifically comment on the consequences for the listed stock parameters with regard to reference points consistent with maximum sustainable yield;
- up-date the description of EU fisheries exploiting these stocks, in terms of fleets, fishing gears, deployed fishing effort (capacity in N°-GT-kW, activity in days at sea, gear characteristics), catches and catch composition, size composition, discards, fishing grounds and seasonality;
- identify knowledge and monitoring gaps for fisheries, stocks, vital fish habitats and other environmental aspects relevant to fisheries in the area and provide information on the reasons for this deficiency and suggest monitoring and scientific actions that need to be developed in the short and mid-term to fill these gaps;
- evaluate the progress made in addressing such gaps since last year;
- evaluate technical measures for Black Sea turbot in the EU Regulation for 2010 for Black Sea stocks[1];
- prepare and/or up-date maps showing geographic density patterns in annual abundance indices derived from surveys aggregated for age groups selected by the fisheries and compare them with maps of geographical distribution patterns in annual landings and discards of sprat and turbot by fishing gear;
- identify other important fisheries and stocks that may be in need of specific management measures and analyze whether the scientific basis needs to be further developed;
- report all results to the STECF Plenary in November 2010.

In support of its advice STECF shall provide for each stock:

a) a full methodological description of the assessment and advisory procedure updated whenever a significant change is made;

b) estimates of landings, fishing mortality, recruitment and spawning stock together with information or estimates of the uncertainty with which these parameters are estimated;

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[1] Council Regulation (EC) No 1287/2009, Annex II

c) where applicable, quantitative and qualitative estimates of IUU (Illegal, Unregulated and Unreported) fishing and its effects on the stocks of such fisheries;

List of stocks to be assessed

Species common name	Species scientific name	FAO CODE
Sprat	*Sprattus sprattus*	SPR
Turbot	*Psetta maxima*	TUR
Whiting	*Merlangius merlangus*	WHG
Anchovy	*Engraulis encrasicolus*	ANE
Mediterranean horse mackerel	*Trachurus mediterraneus*	HMM
Picked dogfish	*Squalus acanthias*	DGS
Rapa Whelk	*Rapana venosa*	RPW

3. STECF OBSERVATIONS

STECF acknowledges the progress in the analytical assessments of sprat and turbot and endorses the report of SGRST-10-03 part B Black Sea as annexed to this report.

4. STECF RECOMMENDATIONS AND CONCLUSIONS

STECF recommends as follows:

4.1. Turbot (*Psetta maximus*) in the Black Sea

FISHERIES: The STECF SG-RST 10-03 noted that the Turbot (*Psetta maxima*) is the one of the most important demersal fish species in the Black Sea with high market demand and prices. Main fishing gear for all coastal states are gillnets, but in Turkey, the bottom trawling is also permitted. The turbot is often caught as a by-catch of sprat fishery, long lines and purse seiners fishery. Turbot catches are higher in spring and autumn periods: March – April and October – November for Bulgaria and Romania; May – June for Ukraine, March - April and September – October for Turkey. STECF estimates that International annual landings of turbot during last 5 years have averaged 858 t and ranged between 730 t and 1035 t. Misreporting and illegal catches also occur.

Prohibition of fishing activity for turbot was in force from 15 April to 15 June in European Community waters of the Black Sea in relation to pick reproduction period of turbot. The minimum legal mesh size for bottom-set nets used to catch turbot is 400 mm. Other technical measures like minimum landing size and by-catch rules are defined.

In Ukraine turbot fisheries are conducted with bottom (turbot) gill nets with mesh size 180 - 200 mm. The use of bottom trawls has been prohibited. Turbot exploitation in Ukraine has been regulated by TACs since 1996.

In Turkey turbot target fisheries is conducted with bottom (turbot) gill nets with minimum mesh size 160 – 200 mm (Tonay, Öztürk, 2003) and with bottom trawls with minimum mesh size 40 mm. The minimum admissible landing size in Turkey is 40 cm total length. In Turkey – no TAC regulation of turbot catches. Seasonal fishing closures in Turkey are: for bottom trawls from 1st September – 15th April and for gillnets – from 1th May up to 30th June.

SOURCE OF MANAGEMENT ADVICE: The management advice is provided by STECF based on assessments performed by its Black Sea Assessment WG. SG Black Sea has applied XSA to assess the stock of turbot, but because of uncertainties about actual catch the assessment is interpreted only in relative terms, i.e. it is considered indicative of trends only.

MANAGEMENT AGREEMENT: The TACs for turbot catches in 2010 and quota allocations are defined in Council Regulation (EC) No 1287/2009. Both for Bulgaria and Romania quotas of each 48 t for each country were permitted (96 t in total). The size of TAC is not based on an analytical procedure but on precautious basis. No management agreement exists with other Black Sea countries. Also mesh size of gillnets is regulated.

REFERENCE POINTS: Currently precautionary reference points are not applied. STECF, based on the results of its subgroup, proposes $F_{0.1}$=0.15 as limit reference point (Fmsy proxy) of exploitation consistent with high long term yields.

STOCK STATUS: SG Black Sea has applied XSA to assess the stock of turbot, but because of uncertainties about actual catch the assessment is interpreted only in relative terms, i.e. it is considered indicative of trends only. Current biomass of turbot is much lower compared to historical levels. The drop in abundance is consistent with the decreases in CPUE and landings. Recruitment has increased since 2003 but this has not materialized in a significant increase in SSB. Despite the recently low TACs the fishing mortality remains at a level certainly higher than the proposed reference point with no signal of reduction.

MANAGEMENT OBJECTIVES: No multi-annual management plan for the European turbot fisheries in the Black Sea exist. Such a plan and its objectives would need to be coordinated between EU and non-EU countries.

RECENT MANAGEMENT ADVICE: STECF considers that the results of the most recent assessment conducted during the STECF-SGRST Working Group in Cadiz in September 2010 are not sufficiently reliable to use as the basis for quantitative management advice on fishing opportunities for 2011. Therefore, in line with its previous advice STECF reiterates that the exploitation of turbot in the Black Sea should be kept at the lowest possible level in order to allow the stock to recover.

STECF COMMENTS: STECF endorses the assessment as conducted by its subgroup on Black Sea fisheries and stock assessments. The quality of such assessments will only impove if reliable catch statistics from all countries are available.

STECF notes that that recent management measures do not appear to have resulted in a reduction in exploitation rates. Furthermore, survey indices do not show any trend in stock biomass.

With reference to the Communication from the Commission (COM (2010) 241 FINAL), STECF advises that turbot in the Black Sea falls under Category 10. Accordingly STECF notes the above category 10 implies a TAC in 2011 of 35 t for each Bulgaria and Romania (70 t in total) based on a 25% reduction in TAC compared to 2010.

4.2. Sprat (*Sprattus sprattus*) in the Black Sea

FISHERIES: The fishing grounds of Black Sea sprat are in the shelf area (up to 100-120m in depth). Sprat fishing with mid-water trawls in EU waters and pair-trawls in Ukraine and in Turkey is undertaken with large fishing vessels (>12m) at mainly at depths between 30 and 60 m. During summer months

(July-August) sprat inhabits deeper water below the thermocline (usually under 10.5 C at 20 m depth),. There is substantial warming up of waters during summer and above the thermocline water temperatures reach 25-27 C°. The sprat fishery is carried out year round, with the highest yields in May-October. In Turkey, the main fishing season is spring (April) and late autumn (November). In 2009, catches increased significantly to about 91,000t mainly due to developing Turkish fisheries.
SOURCE OF MANAGEMENT ADVICE: The management advice is provided by STECF based on assessments performed by its Black Sea Assessment WG. Ukraine and Russian Federation also apply TAC management in their national waters.
MANAGEMENT AGREEMENT: TAC and quota allocations are applied in EU waters of the Black Sea for Bulgaria and Romania. No fishery management agreement exists among Black Sea countries. In the European Black Sea waters a precautious TAC 12 750 t was set for 2010 (Council Reg. No 1287/2009.
REFERENCE POINTS: Currently precautionary reference points are not applied. STECF, based on the results of its subgroup, proposes the exploitation rate of E=0.4 as limit reference point of exploitation consistent with high long term yields (Fmsy proxy). Due to the short life span of sprat resulting in a high natural mortality the yield per recruit analysis and age based production models are not applicable
STOCK STATUS: The analyse of the main population parameters reveals that the sprat stock has recovered from the depression in the 1990s due to good recruitment in 1999-2001 and the biomass and catches have gradually increased over the 1990s and early 2000s. The historic stock estimates, however, confirm the cyclic nature the sprat population dynamics.
Since 2000 SSB has varied without a clear trend at an average level of the past 4 decades.
Fishing mortalities ($F_{1\text{-}3}$) also varied without trend since the 1995 at between 0.4 and 0.6. There is a recent increase estimated in 2009 to F=0.62. This equals to an exploitation rate of about E=0.39 (natural mortality M=0.95). STECF considers thus the stock of sprat in the Black Sea as sustainably exploited.
MANAGEMENT OBJECTIVES: No multi-annual management plan for the European turbot fisheries in the Black Sea exist. Such a plan and its objectives would need to be coordinated between EU and non-EU countries.
RECENT MANAGEMENT ADVICE: STECF recommends a status quo exploitation being applied in 2011. This results in an overall TAC for the sprat in all the Black Sea of 52 100 t. In the absence of an allocation key for the international sprat catches, STECF is unable to advice on a specific EU TAC for sprat in the Black Sea.
STECF COMMENTS: STECF endorses the assessment as conducted by its subgroup on Black Sea fisheries and stock assessments.
With reference to the Communication from the Commission (COM (2010) 241 FINAL), STECF advises that sprat in the Black Sea falls under Category 1. Accordingly, STECF notes the above category 1 rule implies a TAC in 2011 of 52 100 t for the sprat for the entire Black Sea. In the absence of an allocation key for the international sprat catches, STECF is unable to advice on a specific EU TAC for sprat in the Black Sea. STECF notes that a precautionary EU TAC was set at 12 750 t for 2010. STECF notes that the category 1 TAC rule stipulates a maximum annual TAC variation of 25 %.

4.3. Other Black Sea stocks

STECF is presently unable to advise on the state of resources or on fishing opportunities for 2011 for other stocks in the Black Sea.

WORKING GROUP REPORT ON ADVICE ON STOCKS OF INTEREST TO THE EUROPEAN COMMUNITY IN THE BLACK SEA

SGRST-10-03 Part 3b Review of Scientific Advice for 2011

11 – 15 Ocotober 2010 Cádiz, SPAIN

This report does not necessarily reflect the view of the European Commission and in no way anticipates the Commission's future policy in this area

1 EXECUTIVE SUMMARY AND RECOMMENDATIONS

STECF SG Black Sea performed the regular annual stock assessments of sprat and turbot using age structured methods. It also reviewed the state of data and assessments of anchovy, horse mackerel, whiting, dogfish and Rapa whelk and evaluated the potential to perform quantitative stock assessment of these stocks.

The stock assessment of sprat was performed using ICA on catch-at-age data tuned by multiple age structured indices of relative abundance. New data from Ukrainian and Turkish sprat fisheries were added to the input catch-at-age matrix that improved the data quality and consistency of the analyses.

In recent years, recruitment and SSB of sprat are at medium levels of about 100 billions and 250 000 t (207 827 t in 2009), respectively. Short term projections with status quo fishing mortality in 2010 and 2011 result in 52 100 t catch in 2011 and predict that in 2010-2012 SSB will increase from 172 422 to 225 385 t. The estimated MSY of 47 997 t is about the same order of magnitude as the predicted status quo catch (~50 000t) but significantly lower than the actual catch in 2009 of 91 376 t. The sprat fishery is quickly expanding in Turkey which implies that the stock may have some additional (albeit unknown) potential along the Turkish shelf area in the southern Black Sea. The WG notes that the expanding Turkish sprat fishery appears to be largely uncontrolled. Given the high variability of the stock, the short life-span and relatively high natural mortality the WG recommends to use a limit reference point of exploitation rate of E=0.4 (F = 0.63). The recent (2009) fishing mortality is estimated at $F_{(ages\ 1\text{-}3)} = 0.62$.

In order to safeguard the recovery potential of the stock, the WG recommends that the total catches of sprat from the Black Sea are kept at or below the 2010 status quo level, i.e. at or below 52 100 t.

The method of XSA was applied to assess the stock of turbot. The WG made qualitative assumptions about the IUU (Illegal, Unregulated and Unreported) fishing of turbot and estimated the Potential Unreported Catch in 2002-2009. During 2002-2009 the estimated total catch was on average about 59% (1.5 times) higher than the reported landings. The WG considers this value a maximum potential value and assumes that actual catch may range in the region between the estimated and reported catch. Based on the estimated catches the historic assessment was run. The recruitment and SSB based on estimated catches were higher by about 57% and 67% respectively, and the average fishing mortality (F4-8) was 13% lower as compared with the assessment results based on official landings only.

Uncertainties related to official catch figures force the WG to interpret the turbot assessment only in relative terms – i.e. they are considered indicative of trends only. Recent biomass of turbot is estimated to be low compared to historical levels. The recent reduction in abundance is consistent with the decreases in CPUE and landings.

The STECF-Black Sea WG has evaluated reference points based on age structured Yield per Recruit and production models. Recent estimated catches exceed the assessed MSY= 2 457 t. Fishing mortality is rather high: F>0.6 and exceeds both $F_{0.1}$=0.15 and F_{msy}=0.3. Given the present uncertainties about actual catches the WG recommends $F_{0.1}$=0.15 as an appropriate interim target reference point for the exploitation of turbot in the Black Sea.

The WG suggests that in 2010 and in near future the exploitation is kept at a low level in order to allow the stock to recover to historical levels.

The WG evaluated the technical measures for Black Sea turbot in the EU Regulation for 2010 for Black Sea (Council Regulation (EC) No 1287/2009, Annex II). In conformity with Annex II, the minimum mesh size of the gill nets for turbot is 2a= 400mm. The WG agreed that this mesh size is appropriate to protect turbot below the minimum legal size (45cm-TL) and recommends the full implementation of such technical measure.

The WG suggests that special investigations are undertaken in to quantify the extent of IUU fishing on turbot in the Black Sea. The WG notes that inaccurate fisheries data imply low precision in estimated stock parameters and thus a high risk for fisheries management.

Available information on anchovy, horse mackerel, whiting, dogfish and Rapa whelk was reviewed and data needs and availability for stock assessment were discussed. The five stocks were considered to be of primary importance for the fisheries and the ecosystem. The WG recommends that quantitative stock assessment methods shall be applied to these stocks using age and size structured approaches. In order to progress with such assessments there is a need to make additional efforts to properly process historical data and perform assessments (as has been done with sprat and turbot). The assessment of additional exploited stocks would require two additional meetings to be held in 2011 to deal exclusively with anchovy and whiting. It is likely that additional expertise would be needed to undertake such work and carry out the additional assessments. The WG will possibly be unable to provide assessments for horse mackerel, dogfish and Rapa whelk until data of anchovy and whiting have been compiled and respective assessment been undertaken.

2 INTRODUCTION

SGRST-10-03 met during 11–15 October 2010 at the premises of the Inst. Español de Oceanografía (IEO) Cadiz, Spain. The meeting was opened by the chairman Georgi Daskalov on 11 October at 9.00 am and adjourned on Friday 15 October at 4 pm.

2.1 Terms of Reference

Without prejudice, STECF is requested to advice in particular on 2011 catch limitations as well as any additional management or technical measure in line with EU policy objectives and principles for sustainable fisheries management for the stocks listed below.
SG-RST 10-03 is requested to address the following ToR for Black Sea stocks:
compile and provide complete sets of national annual data on landings, discards, landings at age, discards at age, mean weight at age in the landings, mean weight at age in the discards, maturity ogives at age and natural mortality at age by area for the longest time series available up to and including 2009. The data should be compiled based on official data bases, best expert knowledge and by using the results of scientific surveys.
compile and provide all fishery independent data (pelagic, demersal, hydro-acoustic surveys) for the stocks as available, their juveniles, eggs or early life stages. In order to allow the use of such data to potentially calibrate virtual population analyses, the abundance, biomass and spawning stock biomass indices at age should be compiled for the longest time series available up to and including 2010.
compile and provide complete sets of annual fishing effort data (number of vessels, kW*days, fished hours) by nation, for fleets and gears (mesh size where applicable), and area for the longest time series available up to and including 2009.
assess trends in historic stock parameters for the longest time series available up to and including 2010 (fishing mortality at age, spawning stock biomass, stock biomass, recruits at age). Different assessment models should be applied as appropriate, including analyses of retrospective effects.
review and evaluate existing management measures and suggest additional measures in the short and medium term as well as long term management strategies in accordance with EU policy on fisheries;
propose and evaluate candidate limit and target reference points consistent with maximum sustainable yield and precautionary approach;
predict spawning stock biomass, stock biomass, recruits and catches at age and in weight in 2010, 2011 and the beginning of 2012 under different management scenarios including the status quo fishing (mean F at age 2008-2010, rescaled to 2010) and with a TAC constraint for 2010. Specifically comment on the consequences for the listed stock parameters with regard to reference points consistent with maximum sustainable yield;
up-date the description of EU fisheries exploiting these stocks, in terms of fleets, fishing gears, deployed fishing effort (capacity in N°-GT-kW, activity in days at sea, gear characteristics), catches and catch composition, size composition, discards, fishing grounds and seasonality;
identify knowledge and monitoring gaps for fisheries, stocks, vital fish habitats and other environmental aspects relevant to fisheries in the area and provide information on the reasons for this deficiency and suggest monitoring and scientific actions that need to be developed in the short and mid-term to fill these gaps;
evaluate the progress made in addressing such gaps since last year;

evaluate technical measures for Black Sea turbot in the EU Regulation for 2010 for Black Sea stocks[2];
prepare and/or up-date maps showing geographic density patterns in annual abundance indices derived from surveys aggregated for age groups selected by the fisheries and compare them with maps of geographical distribution patterns in annual landings and discards of sprat and turbot by fishing gear;
identify other important fisheries and stocks that may be in need of specific management measures and analyze whether the scientific basis needs to be further developed;
report all results to the STECF Plenary in November 2010.

In support of its advice STECF shall provide for each stock:
a full methodological description of the assessment and advisory procedure updated whenever a significant change is made;
estimates of landings, fishing mortality, recruitment and spawning stock together with information or estimates of the uncertainty with which these parameters are estimated;
where applicable, quantitative and qualitative estimates of IUU (Illegal, Unregulated and Unreported) fishing and its effects on the stocks of such fisheries;

List of stocks to be assessed

Species common name	**Species scientific name**	**FAO CODE**
Sprat	*Sprattus sprattus*	SPR
Turbot	*Psetta maxima*	TUR
Whiting	*Merlangius merlangus*	WHG
Anchovy	*Engraulis encrasicolus*	ANE
Mediterranean horse mackerel	*Trachurus mediterraneus*	HMM
Picked dogfish	*Squalus acanthias*	DGS
Rapa Whelk	*Rapana venosa*	RPW

2.2 Participants

The full list of participants at SGRST-10-03 part B is presented in Appendix 1. Appendix 2 documents the experts' declarations.

2.3 WG acchievments in relation to ToR

STECF SG Black Sea ToR achievements

STECF SG Black Sea met in Oct 2010 in IEO in Cadiz and addressed the following ToR:

Compile and provide complete sets of national annual data on landings, discards, landings at age, discards at age, mean weight at age in the landings, mean weight at age in the discards, maturity ogives at age and natural mortality at age by area for the longest time series available up to and including 2009. The data should be compiled based on official data bases, best expert knowledge and by using the results of scientific surveys.

2 Council Regulation (EC) No 1287/2009, Annex II

Data were compiled for sprat and turbot. New complete data on age structure of Ukrainian sprat fishery were added to the input catch-at age matrix. The timing of the meeting of the STECF SG Black Sea was convenient in order to have official (and most reliable) fisheries information from Turkey.

Compile and provide all fishery independent data (pelagic, demersal, hydro-acoustic surveys) for the stocks as available, their juveniles, eggs or early life stages. In order to allow the use of such data to potentially calibrate virtual population analyses, the abundance, biomass and spawning stock biomass indices at age should be compiled for the longest time series available up to and including 2009.

Data were compiled for sprat and turbot. New commercial Turkish CPUE tunning index was constructed and used in stock assessment of turbot, as well as Bulgarian research survey tunning index.

Compile and provide complete sets of annual fishing effort data (number of vessels, kW*days, fished hours) by nation, for fleets and gears (mesh size where applicable), and area for the longest time series available up to and including 2009.

Available data are presented for sprat and turbot. The WG is satisfied by the effort made by the national fisheries administrations in Bulgaria and Romania to compile and provide fishing effort data.

Assess trends in historic stock parameters for the longest time series available up to and including 2009 (fishing mortality at age) and up to and including 2009 (spawning stock biomass, stock biomass, recruits at age). Different assessment models should be applied as appropriate, including analyses of retrospective effects.

In recent years, recruitment and SSB of sprat are at medium levels of about 100 billions and 250 000 t (207 827 t in 2009), respectively. Average fishing mortality (F1-3) is between 0.4 and 0.6.

Review and evaluate existing management measures and suggest additional measures in the short and medium term as well as long term management strategies in accordance with EU policy on fisheries;

Current regulations and management practices for sprat and turbot in EU and non EU countries in the Black Sea were reviewed.

Propose and evaluate candidate limit and target reference points consistent with maximum sustainable yield and precautionary approach;

The WG recommends to use the exploitation rate of 0.4 (F = 0.63) in sprat, and F0.1 =0.15 in turbot, (considered as proxies of Fmsy) as upper limit reference points.

Predict spawning stock biomass, stock biomass, recruits and catches at age and in weight in 2010, 2011 and the beginning of 2012 under different management scenarios including the status quo fishing (mean F at age 2007-2009, rescaled to 2009) and with a TAC constraint for 2010 Specifically comment on the consequences for the listed stock parameters with regard to reference points consistent with maximum sustainable yield;

Short term projections with status quo fishing of around 50 000t annual catch predict that in 2010-2012 the sprat SSB will increase from 172 422 to 225 385 t (24 %). Short term projections were not carried out in turbot.

Up-date the description of EU fisheries exploiting these stocks, in terms of fleets, fishing gears, deployed fishing effort (capacity in N°-GT-kW, activity in days at sea, gear characteristics), catches and catch composition, size composition, discards, fishing grounds and seasonality;

Description of EU fisheries was updated.

Identify knowledge and monitoring gaps for fisheries, stocks, vital fish habitats and other environmental aspects relevant to fisheries in the area and provide information on the reasons for this deficiency and suggest monitoring and scientific actions that need to be developed in the short and mid-term to fill these gaps;

The WG partly addressed this issue. A synopsis of the achievements and remaining problems in the work was discussed. More information is needed about intensely developing Turkish sprat fishery (age composition, abundance indices).

Evaluate the progress made in addressing such gaps since last year;

The WG made qualitative assumptions about the IUU fishing of turbot and estimated the Potential Unreported Catch in 2002-2009. The WG considers catch amended with the IUU estimate as a maximum potential value and assumes that actual catch may lay in the region between the estimated and reported catch. The WG suggests that special investigations need to be performed in future in order to better identify the levels of IUU of turbot.

Evaluate technical measures for Black Sea turbot in the EU Regulation for 2010 for Black Sea stocks

The WG evaluated the technical measures for Black Sea turbot in the EU Regulation for 2010 for Black Sea (Council Regulation (EC) No 1287/20009, Annex II). In conformity with annex II, the minimum mesh size of the gill nets for turbot is 2a= 400mm. The WG agreed that this mesh size is correct and protects the minimum legal size of the turbot (45cm-TL) and suggests the implementation of the proposed technical measures.

Prepare and/or up-date maps showing geographic density patterns in annual abundance indices derived from surveys aggregated for age groups selected by the fisheries and compare them with maps of geographical distribution patterns in annual landings and discards of sprat and turbot by fishing gear;

Maps of surveys catch rates were created and distribution patterns were discussed. Data on landings distributions are not available.

Identify other important fisheries and stocks that may be in need of specific management measures and analyze whether the scientific basis needs to be further developed
Given the constraints of time and capacity the WG was able perform routine assessments of the sprat and turbot stocks only.

Available information on anchovy, horse mackerel, whiting, dogfish and Rapa whelk was reviewed and data needs and availability for stock assessment were discussed. The five stocks were judged to be of primary importance for the fisheries and the ecosystem. The WG considers that some form of quantitative stock assessment can be applied to these stocks using age and size structured methods. Input data for such assessments would consist in time series of catches and relative abundance indices. In order to proceed with such assessments the STECF will need to organise additional meetings to properly process historical data and perform assessments (as it was done with sprat and turbot). A road map for assessing additional stocks in future was drawn proposing two additional meetings to be held in 2011 to deal with anchovy and whiting. The needs of additional experts to join the SG in relation to the new assessments were discussed. After completing stock assessments of these stocks, the WG will be able to deal with the rest of the stocks e.g. horse mackerel, dogfish and Rapa whelk

3 DCF DATA CALL TO SUPPORT SGRST-10-03 PART

3.1 Data policy

Working Group members were reminded that data collected under the DCF call and supplied to SGRST-10-03 could NOT be used outside the meeting. The data are stored by the EU to enable future assessments under the auspices of STECF or related groups, to be performed without the need to produce further DCF calls.

3.2 Data call

On the 5th of August 2010 DG MARE launched an official call for Review of Stock Assessment and Fisheries Management Advice of Black Sea stocks. Due to communication difficulties between DG MARE and JRC, the data call was finally sent off by JRC to the National Correspondents on the 7th of September. Due to the late delivery of the data call to the National Correspondents, the possibility of uploading data after the official deadline for the submission was offered to the Member States.

Member States were invited to provide, as soon as possible and not later than 10 of September 2010, data collected under National Data collections programmes and surveys as detailed in Commission Regulations (EC) 1639/2001 and 1581/2004 for data prior to 2009 and Commission Decision 2008/949/EC for the time period 2009-2010 as well as data collected prior to accession to the EU and in research projects funded by the EU or National level until 2009, to the Commission (JRC server for data collection framework DCF) and to the scientists that would attend the forthcoming STECF-SGRST-10-03 meeting in Cadiz, Spain (11-15 October 2010). The meeting was organized in order to review the scientific advice for widely distributed and Black Sea stocks, and stocks and fisheries located in Outermost Regions. The 2010 DCF Black Sea data call is fully documented at: https://datacollection.jrc.ec.europa.eu/data-calls

The Black Sea data call was managed as an extension of the SGMED data call earlier this year (May 2010) and the format and the templates were kept the same.

The call covered the years:
2002-2010* for fisheries data,
2008-2010* for bottom trawl and pelagic trawl surveys

* Data for 2010 should be provided as available by 10 September 2010.

Fisheries data were requested for the following species:
Sprattus sprattus (Sprat)
Psetta maxima (Turbot)

Merlangius merlangus (Whiting)

and the variables stated below:

Landings
Effort
Length distribution of landings
Age distribution of landings
Maturity ogive at length
Maturity ogive at age
Growth parameters
Sex ratio at length
Sex ratio at age
Discards
Length distribution of discards
Age distribution of discards

Further data on more stocks were expected to be uploaded before 10 September 2010.: i) additional species as included in the data collection regulations and for which Member States are invited to provide relevant data (Table 3.2.1.) and ii) additional species not included in the data collection regulations and for which interested Member States are invited to provide relevant data (Table 3.2.2).

Table 3.2.1 Additional species as included in the data collection regulations and for which Member States are invited to provide relevant data.

Species common name	Species scientific name	FAO CODE
Anchovy	*Engraulis encrasicolus*	ANE
Mediterranean horse mackerel	*Trachurus mediterraneus*	HMM
Horse mackerel	*Trachurus trachurus*	HOM
Piked dogfish	*Squalus acanthias*	DGS

Table 3.2.2 Additional species not included in the data collection regulations and for which interested Member States are invited to provide relevant data.

Species common name	Species scientific name	FAO CODE
Rapa whelk	*Rapana venosa*	RPW

The survey data referred to the Bottom Trawl Survey (main target species turbot) and the Pelagic Trawl survey (main target species sprat and whiting). From the bottom trawl and the pelagic trawl surveys data were requested for the:

Length structure
Age structure
Maturity at age

Economic data were not requested for Black Sea fisheries.

3.3 Preparatory work and technical facilities

Since the beginning of 2010 and following the requirements of the administrative arrangement with DG MARE, JRC further developed the dedicated DCF website (https://datacollection.jrc.ec.europa.eu/) to make it more user friendly and accessible for data providers and the appropriate data infrastructures were designed to host the collected data. At the same time, JRC developed quality assurance aspects of the data submitted by Member States by:

a) using automatic quality checking tool to check the quality and validate the data provided by Member States,
b) evaluating the data provided by Member States and identify missing values,
c) creating special data structures (e.g. tables) to allow monitoring of incoming data and its compliance with the requirements of the data call.

More specifically, during the uploading process the following checks were made:

a) Syntactic checks: Data type and size (reject any data that does not confirm to the given restrictions, ie. Values > 0, ratios between 0-1, upper and lower bounds of the variables)
b) Semantic checks: Constraints on variable values/contents also based on other variables
c) Completeness checks (missing values)
d) Coverage status of submitted data (years, areas, fleet segments)
e) Data duplication checks (double records)

In case of error, an error message is produced, with description and position of the erroneous data.

Since the Black Sea data call was managed as an extension of the SGMED data call in May 2010 and the format and the templates were kept the same, JRC made the necessary modifications and amendments to the database and the data collection website in order to be prepared technically to receive data in September 2010.

3.4 Uploading process by Member State

According to the data call the deadline for submission of data was set for the 10th of September. Due to the late delivery of the data call to the National correspondents by JRC, the possibility of uploading data after the deadline for the submission was provided to the Member States.

This was the first year that data were requested by the Member States in the form of an official data call. In 2010, JRC further developed the dedicated DCF website and applied quality assurance controls on the data submitted by Member States. The data during uploading and before storage in the JRC database were quality checked and wrong codifications, missing or extreme values were identified and the list of errors was reported to the data providers. The files accepted during the uploading process must conform to the templates given as examples on the website. Inconsistencies in the data aggregation and codification were leading to an unsuccessful upload. JRC experts were always monitoring the upload procedure and after consultation with some of the data providers, necessary modifications to the database were done, in order to facilitate the upload procedure.

Bulgaria: On the 8th of September Bulgaria requested additional time to upload the biological and surveys data due to the fact that the scientists received the data call with some delay. The first set of data was uploaded on the 14th of September for effort, discards and age distribution of discards. Bottom trawl survey data were uploaded on the 7th and 8th of October, along with the growth parameters and the sex ratio files (by age and by length). The pelagic trawl survey data files were submitted on the 11th of October, the first day of the SGRST-10-03 meeting.

Romania: Romania managed to upload the survey data before the deadline. The growth parameters, along with the bottom trawl and the pelagic trawl survey data were submitted on the 8th of September (except the length distribution of the bottom trawl, which was successfully uploaded two days later). The length and age distribution of the landings were successfully uploaded on the 29th of September, whereas the landings and effort data on the 7th of October.

3.5 Conclusions and recommendations for future DCF data calls

In order for JRC to process and prepare the data for the assessment working groups, the datasets need to be available well in advance (4 weeks) before the beginning of the relevant assessment meetings. No data should be accepted after the deadline for submission. Any progress in data submissions in terms of compliance with uploading procedures and data consistencies will facilitate the necessary preparations for the STECF working groups.

4 BLACK SEA STOCK ASSESSMENTS

4.1 Sprat in the Black Sea

4.1.1 Stock Identification

The Black Sea sprat (*Sprattus sprattus L.*) is a key species in the Black Sea ecosystem. Sprat is a marine pelagic schooling species, sometimes entering in the estuaries (especially as juveniles) and tolerating salinities as low as 4‰. In the daytime, it keeps to deeper water and in the night moves near the surface. It forms big schools and undertakes seasonal movements between foraging (inshore) and spawning (open sea) areas (Ivanov and Beverton 1985). Adults tend to remain under the seasonal thermocline, penetrating above its only during the spring and autumn homothermia. Juveniles are distributed in a larger area near the surface. Sexual maturity is attained at the age of 1 year and length of 7 cm. In Turkey it was found that males reached maturity at 7.5 cm and females at 7.8 cm at age 1 year (Avşar & Bingel, 1994).

Sprat is one of the most important fish species, being fished and consumed traditionally in the Black Sea countries. It is most abundant small pelagic fish species in the region, together with anchovy and horse mackerel and accounts for most of the landings in the north-western part of the Black Sea. Whiting is also taken as a by-catch in the sprat fishery, although there is no targeted fishery beyond this (Raykov, 2006).

Sprat fishing takes place on the continental shelf on 40-100 m of depth. The harvesting of the Black Sea sprat is conducted during the day time when its aggregations become denser and are successfully fished with trawls. The main fishing gears are mid-water otter trawl and uncovered pound nets.

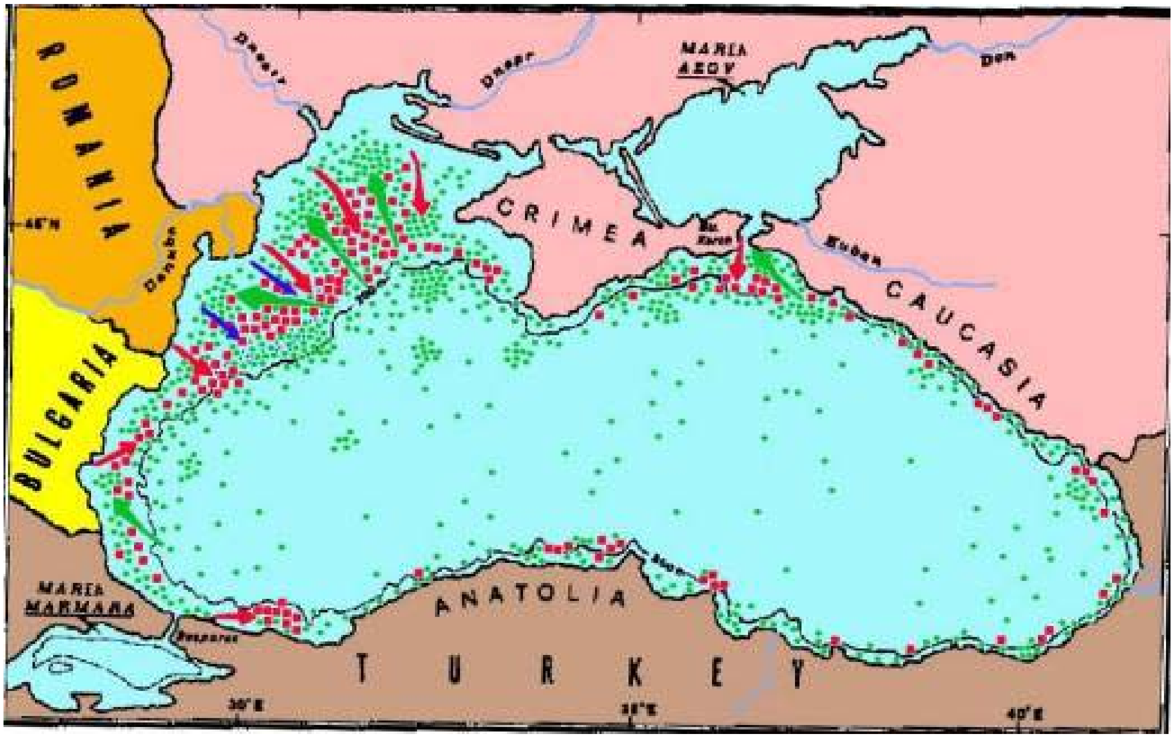


Figure 4.1.1.1. Sprat distribution and migration in the Black Sea

Legend: Wintering areas and migration to | Spawning areas and migration to them | Feeding areas and migration to them

4.1.2 Growth

The species is fast growing; age comprises 4+ age groups. The VBGF parameters by countries are given in Table 4.1.2.1. In Romanian waters asymptotic length and growth rate is comparable with the growth parameters derived in Bulgarian Black Sea waters.

Table 4.1.2.1 VBGF parameters calculated in the Black Sea

	L∞	**k**	**t_0**	**a**	**b**
Bulgaria	13.5	0.33	-0.56	0.00011	3.11
Romania	13.68	0.258	-1.88	0.004983	3.0704
Ukraine	11.68	0.29	-1.5	0.0011	3
Turkey	10.32	0.867	-0.651	0.0067	2.9446

Sprat has lengths comprised among 50 and 135 mm, the highest frequency pertaining to the individuals of 70-100 mm lengths.

The age corresponding to these lengths was 0+ - 4-4+, the ages 2-2+ - 3-3+ having a significant participation. By 1982, the age classes 4-4+ years had a share of 34% from the catch of this species, then the percentage continually decreased up to 1995 when this age was not signalled, meaning the increase of the pressure through fishing exerted on the populations. While the share of this age decreased, the prevalence of 0+ especially 1-1+ ages became increased. During last years the age structure show the presence of the specimens of $1\text{-}1^{+}$ and $3;3^{+}$ years, the catch base being the individuals of $1\text{-}1^{+}$ and $2\text{-}2^{+}$ years.

Table 4.1.2.2 Size distribution of sprat in the western part of the Black Sea.

Species	Year	Range of length (mm)	Dominant class (mm)	Mean length (mm)	Mean mass (g)	Dominant age (years)
Sprat	1995	55-105	75-90	85.0	4.7	2; 3
	1996	60-115	75-95	85.2	5.0	2
	1997	60-115	80-100	86.6	5.6	2; 3
	1998	40-13	80-100	85.9	4.8	2; 3
	1999	55-125	70-95	83.8	3.9	1; 2
	2000	55-120	80-95	87.5	3.8	2; 3
	2001	55-120	80-100	86.57	3.86	2; 3
	2002	55-130	85-100	87.88	4.05	2;3
	2003	65-125	80-100	101.61	3.84	2;3
	2004	65-125	75-95	85.75	399	2;1
	2005	65-130	75-100	88	4.097	2;1;3
	2006	45-135	65-95	75.3	3.046	1;2
	2007	65-130	78 -97	88.6	4.6	1;4
	2008	55 - 130	65 - 100	84.132	3.655	1;3
	2009	50-130	75-95	86.88	4.1	1;3

Fig. 4.1.2.1 displays the length distribution by strata. At depth of 50m toward 70m the percentage of the bigger length classes increased.

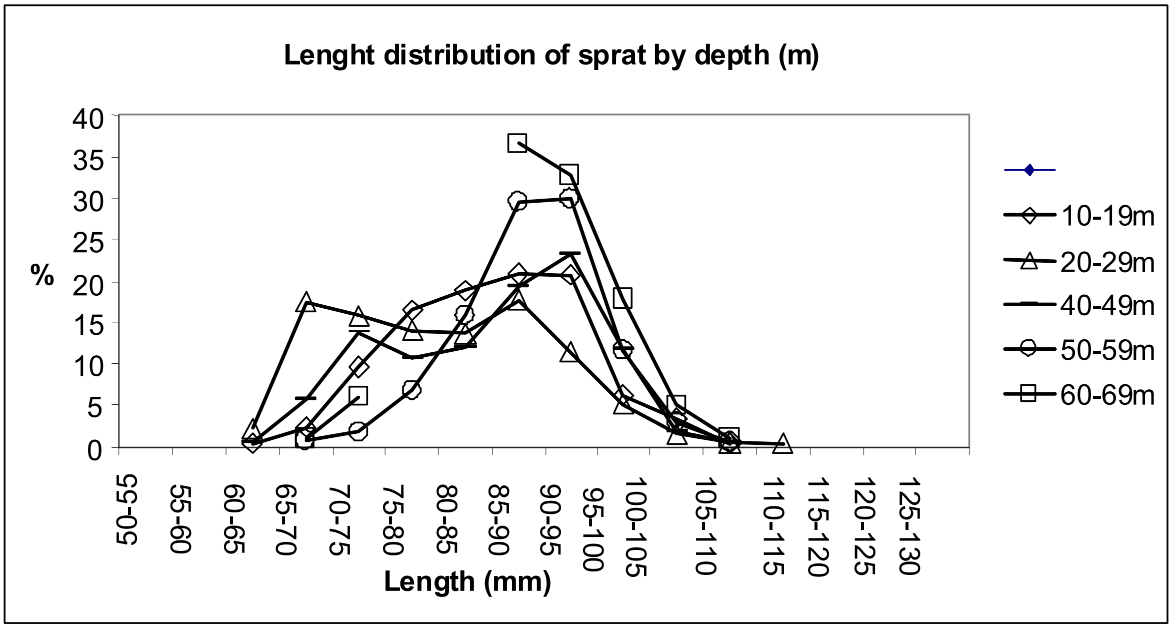


Figure 4.1.2.1. Length distributions in different strata. Data from surveys in Romanian part of the Black Sea

4.1.3 Maturity

The analysis of the gonad maturation (Table 4.1.3.1) shows that the majority of specimens were in the VI-II and II degree of maturation during fishing season. Peak spawning activity take place in December-February.

Table 4.1.3.1 Maturity of sprat.

Year	Month	Sex	Degree of gonad maturation									
			II	II-III	III	III-IV	IV	IV-V	V	V-VI	VI	VI-II
2009	IV	F	88.6									11.4
		M	90.4									9.6
	V	F	80.2	7.9								11.9
		M	75.8	23.5								0.7
	VI	F	95.4	4.6								
		M	92.8	7.2								
	VII	F	91.7	8.3								
		M	87.3	12.7								
	VIII	F	80.8	8.5	10.7							
		M	75.8	20.5	3.5							
	IX	F	58.7	23.3	15.2	2.8						
		M	53.9	26.6	18.6	0,9						
	X	F	26.8	36.5	28.1	8.6						
		M	23.4	32.9	40.2	3.5						
	XI	F	55.2	28.7	13.6	2.5						
		M	42,3	23.6	20.5	13.6						

4.1.4 Fisheries

4.1.4.1 General desciption

The sprat fishery is taking place in the Black Sea (GFCM Fishing Sub-area 37.4 (Division 37.4.2) and Geographical Sub-area (GSA) 29). The opportunities of marine fishing are limited by the specific characteristics of the Black Sea. The exploitation of the fish recourses is limited in the shelf area. The water below 100-150 m is anoxic and contains hydrogen sulphide. The most intensive fisheries of Black Sea sprat is conducted in April till October with mid-water trawls on vessels 15-30 m long and a small number vessels >30m. Beyond the 12-mile zone a special permission is needed for fishing. Harvesting of Black Sea sprat is conducted during the day, when the sprat aggregations become denser and are successfully fished with mid-water trawls.

The significance of the sprat fishery in Turkey in the last three years has increased and the landings reached 53 385 t in 2009. The main gears used for sprat fishery in Turkey (fishing area is constrained in front of the city of Samsun) are pelagic pair trawls working in spring at 20-40m depth and in autumn - in deeper water: 40-80m depths. Figure 4.1.4.1.1 provides the scheme of location of prohibited grounds (red color) and permitted grounds (yellow color) for trawl fisheries of sprat in Ukraine.

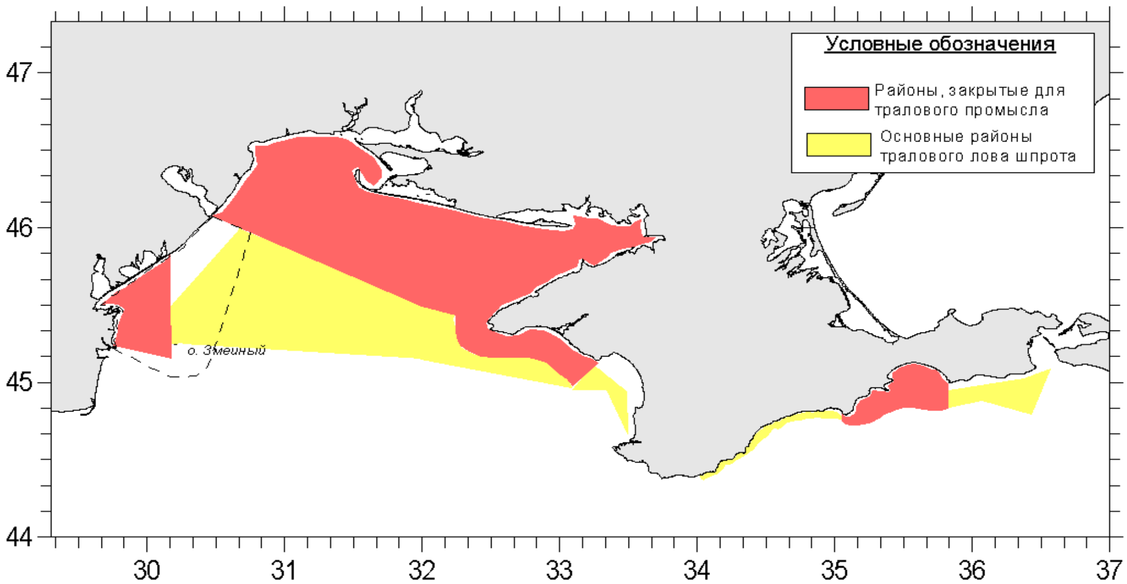


Fig. 4.1.4.1.1 The main grounds for Black Sea sprat fisheries in the Ukraine. Red shaded areas: closed for fishing; yellow shaded areas: sprat main fishing grounds.

4.1.4.2 Management regulations applicable in 2009 and 2010

A quota is allocated in EU waters of the Black Sea (Bulgaria and Romania). No fishery management agreement exists between other Black Sea countries. In the EU Black Sea waters a global (both Romania and Bulgaria) TAC 12 750 tons has been allocated in 2009 and 2010. This figure is a result of a reduction of the 2008 TAC of 15 000 t based on the precautionary principle. Ukraine and Russian Federation also apply TAC in their national waters (Table 4.1.4.2.1). Minimum landing size of sprat is applied across the region except in Turkish waters (Table 4.1.4.2.2.).

Table 4.1.4.2.2. Sprat TAC applied in Ukraine and Russian Federation in tons.

Year	Russian Federation	Ukraine
2005	42 000	60 000
2006		70 000
2007		40 000
2008	21 000	50 000
2009	21 000	50 000
2010	21 000	50 000

Table 4.1.4.2.2. Minimum landing size of sprat in the Black sea region

	BG	GE	RO	RU	TR	UA
Sprattus sprattus phalericus	**TL= 7cm**	**SL = 6cm**	**TL=7cm**	**SL=6cm**	**no**	**SL=6cm**

4.1.4.3 Landings

Catch and landings of the sprat in the Black Sea were reported by the Black Sea countries and data from Bulgaria and Romania were collected and reported for the Data Collection Program from National agencies for fisheries and aquaculture in both countries. Mid-water trawl catches dominate the landings.

Landings significantly increased in the last years due to intensification of the sprat fishery in Turkey (but also a gradual increase is reported by Bulgaria, Russia, and Ukraine). Romanian catches decreased to 92 tons in 2009 (Tab. 4.1.4.3.1.).

Table 4.1.4.3.1. Sprat landings in the Black Sea.

	Bulgaria	*Bulgaria	Romania	Romania*	Ukraine	Turkey	Turkey	Georgia	Russian Federation	Total
1970	1407		2678		353	0		0		4438
1971	2473		2517		846	0		0		5836
1972	2962		23		884	0		0	16	3885
1973	3383		22		878	0		0	22	4305
1974	4468		1245		477	0		0	23	6213
1975	5565		731		787	0		0	43	7126
1976	7199		161		1594	0		0	16	8970
1977	8754		1463		4346	0		0	2354	16917
1978	10596		149		1949	0		1	3317	16012
1979	13541		2269		36757	0		3466	17700	73733
1980	16568		989		47635	0		4571	14687	84450
1981	1888		2283		49175	0		5781	20165	79292
1982	16524		3004		3862	0		2462	15266	41118
1983	12023		3406		20755	0		886	3843	40913
1984	13921		4456		18021	0		847	5270	42515
1985	15924		6836		23657	0		1817	3365	51599
1986	1169		8979		33147	0		2939	7010	53244
1987	10979		9474		43158	0		697	8972	73280
1988	6199		6454		39835	0		7172	7157	66817
1989	7403		8911		63239	0		9708	16045	105306
1990	2651		3198		33174	0		6895	6955	52873
1991	1909		729		11094	0		2313	2675	17082
1992	2353	3266*	2074		11492	0		830	3221	19970
1993	2174	3705*	2439		9154	640		32	694	15133
1994	2200		2203		12615	700		308	1013	16861
1995	2874		1982		15218	157		288	1263	21782
1996	3535		2014		20720	937		185	1537	10280
1997	3646		3318		20208	468	3500**	85	706	28431
1998	3275		3293		30282	1236	3000**	24	1243	39353
1999	3595		1933		29238	421	2000*	45	4473	39705
2000	1737		1803		32644	6225	5000*	42	5543	47994
2001	695		1792		48938	1008	4000*	40	11122	63595
2002	11595		1617		45430	1965	7000*	34	11218	30972
2003	9155		1219		31366	5775	3804*	2	204	47721
2004	2889	7997*	135		30891	5186	4906*	12	143	39256
2005	2575	6500*	1487		35707	5271	8170*	19	1316	46375
2006	2655	8183*	492	1400*	21308	6681	11039*		8157	39293
2007	2559	2985*	208	400*	18013	11725	14800*		6077	39200
2008	4304		234		21111	39903	18000*		7814	51463
2009	4551		92		24603	53385			8744	91376
Total										

* expert assessments
**Sprat plants reported (CFRI) tons - Turkey
***pending official statsitics reports

Discards

No discards have been reported for the sprat fishery with mid-water otter trawls with the exception of Romanian official reports stating that sprat discards account 1 ton in 2009.

4.1.4.4 Fishing effort

Table 4.1.4.4.1. Mid-water trawl fishing effort in European waters of the Black Sea.

COUNTRY	AREA	YEAR	FT_LVL3	FT_LVL4	FT_LVL5	FT_LVL6	DAYS	GTDAYS	KWDAYS
BGR	29	2009	PT	OTM	MDPSP	12SXX	1671	207590.38	409072.35
BGR	29	2009	PT	OTM	MDPSP	12SXX	573	36160.33	118870.3
BGR	29	2008	PT	OTM	MDPSP	12SXX	1379	171135	335647
BGR	29	2008	PT	OTM	MDPSP	12SXX	430	28081	83527
BGR	29	2008	PT	OTM	MDPSP	12SXX	323	8254	66989
BGR	29	2007	PT	OTM	MDPSP	12SXX	1436	169246.3	322022.4
BGR	29	2007	PT	OTM	MDPSP	12SXX	278	6787	65598
BGR	29	2007	PT	OTM	MDPSP	12SXX	275	6689.52	65200.74
ROM	29	2002	PT	OTM	MDPSP	00D14	878	706790	1862238
ROM	29	2003	PT	OTM	MDPSP	00D14	743	769005	2026161
ROM	29	2004	PT	OTM	MDPSP	00D14	762	701040	1847088
ROM	29	2005	PT	OTM	MDPSP	00D14	788	815580	2148876
ROM	29	2006	PT	OTM	MDPSP	00D14	760	699200	1842240
ROM	29	2007	PT	OTM	MDPSP	00D14	290	100050	263610
ROM	29	2008	PT	OTM	MDPSP	00D14	99	22770	59994
ROM	29	2009	PT	OTM	MDPSP	00D14	56	19320	50904

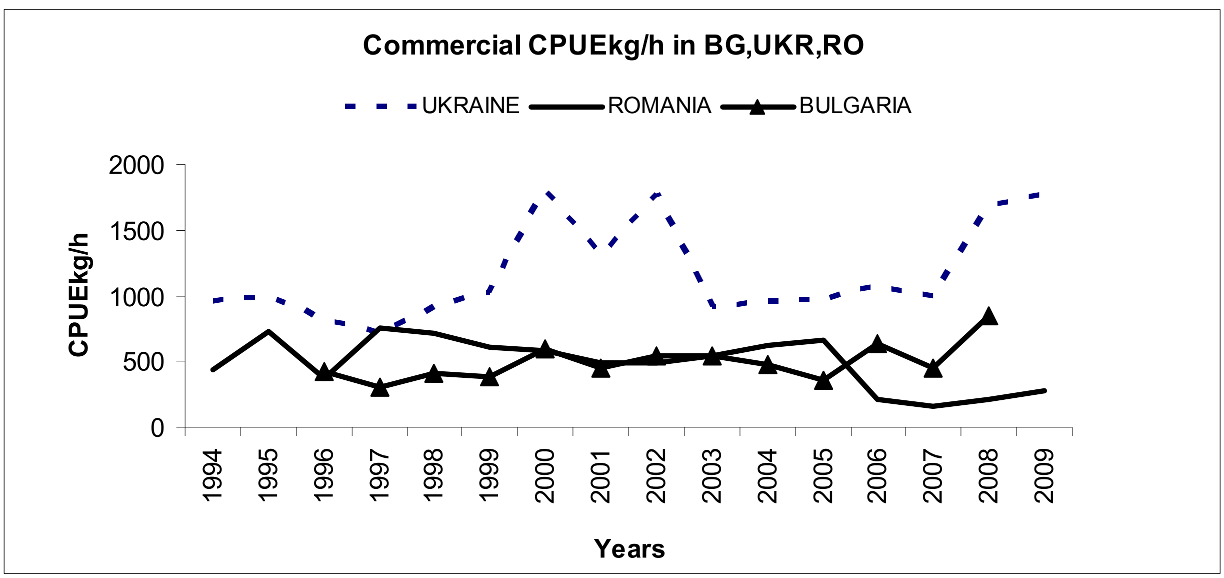


Figure 4.1.4.4.1. CPUE kg/h derived from commercial fishery in Bulgaria, Ukraine and Romania

CPUE kg/h as used in the analysis of the working group are CPUE = 845kg/h (2008) and 1171 kg/h (2009) as derived from the Bulgarian commercial fishery.

Table 4.1.4.4.2. Average CPUE kg/h of sprat in Bulgaria, 2008-2009.

Fleet Segment	*LOA > 0< 6*		*LOA => 6<12*		*LOA => 12<18*		*LOA => 18<24*		*LOA => 24<40*	
*Average CPUE**	*2008*	*2009*	*2008*	*2009*	*2008*	*2009*	*2008*	*2009*	*2008*	*2009*
European sprat SPR	291.22	62.13	214.9	163.78	487.71	542.79	1202.32	1798.81	2444.43	2456.89

Legend: xxx - the CPUE for 2009 decreased compared to 2008; xxx - the CPUE to retain in 2009 compared to 2008; xxx - CPUE increased in 2009 compared to 2008

Comments: As it is visible from the table there is decreasing of the fishing effort for 3 segments (for LOA => 12<18; LOA => 18<24; LOA => 24<40). Having regard that the effort for segment LOA => 6<12 increase with ≈ 30 % and LOA > 0<6 increase with ≈54 % we evaluate these segments in red field.

The Ukraine sprat fishing has been carried out by 16 fishing vessels from March to October 2009. The maximum catch per trawl was observed in June-July (Tab. 4.1.4.4.3).

Tab. 4.1.4.4.3. Catch, effort and mean CPUE kg/h of Ukrainian fishing vessels, 2009.

Ukranian Black Sea waters catch and effort							
January	8		1.86	2.39		5.32	9.24
February	6		2.16	3.48		6.22	10.75
Mart	5	1.99	3.9	8.24	6.29	11.09	22.09
April	7	3.33	3.35	8.34	8.52	9.41	25.72
May	3	4.45	3.41	9.83	13.81	9.31	28.9
June	5	3.31	3.32	8.69	9.32	8.84	30.79
July	4	3.47	3.5	8.67	9.49	9.56	31.12
August	5	2.48	3.46	8.05	5.58	7.54	26.14
September	7	2.91	3.5	8	7.34	10.1	22.52
October	3	0.63	2.16	4.22	2.53	3.45	11.47
Average No.vessels	5.3	-	-	-	-	-	-
Average catch per trawl	-	2.8	3.1	7	-	-	-
Mean CPUE kg/h	-	1.41	1.53	3.5	-	-	-
Average catch of one vessel per day	-	-	-	-	7.86	8.08	21.87

The Turkish sprat fishery has been carried out in spring and autumn/winter period with pelagic trawls for around 90 days in 2009 (Fig. 4.1.4.4.2).Turkish sprat landings have increased significantly after 2006 and especially since 2008 (Fig. 4.1.4.4.3).

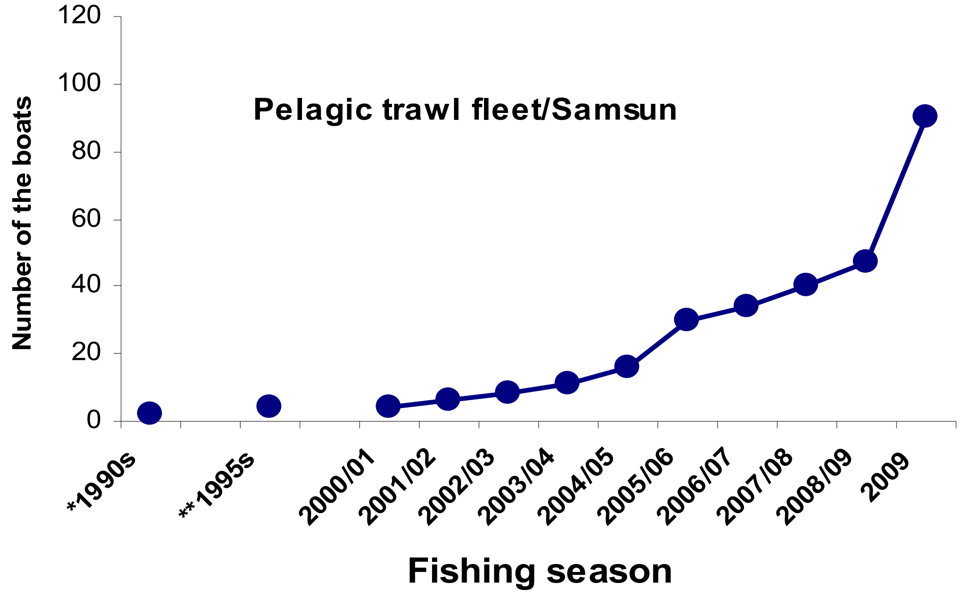


Figure 4.1.4.4.2. Trend in fishing effort of the Turkish pelagic sprat trawl fleet.

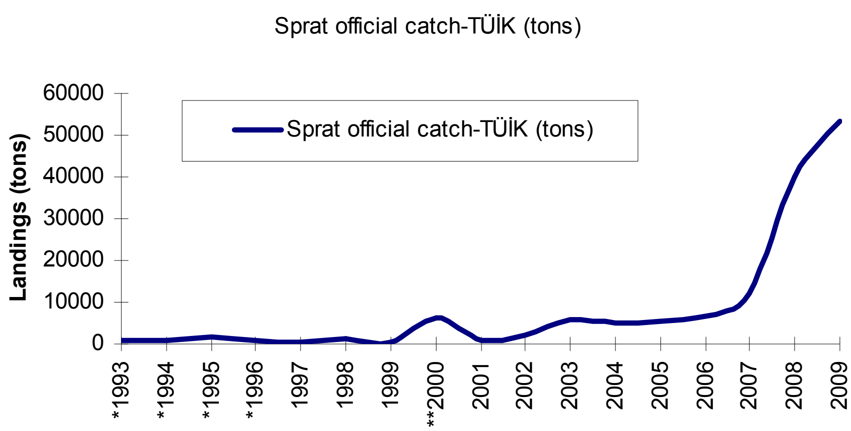


Figure 4.1.4.4.3. Trend in Turkish sprat landings in the Black Sea.

Total number of the fishing vessels operating using mid-water trawls in Romanian Black sea waters was 160. Prevailing LOA class (6-<12 m) accounts 139 vessels (Tab. 4.1.4.4.4)

Table 4.1.4.4.4. Mid-water trawls operating in Romanian sprat fishery, 2009.

Length class LOA (m)	< 6	6 – <12	12-<18	18 – <24	24 – <40	> 40	Total
Total vessels	53	405	9	6	18	-	491
Active vessels	14	139	3	1	3	-	160
Midwater otter trawl Mixed demersal and pelagic species	-	-	-	-	3	-	3

Sprat fishing in Romanian waters is limited to the 60-70 m depth isobaths, as a consequence of the characteristics of the vessels and their limited autonomy (Fig. 4.1.4.4.4.).

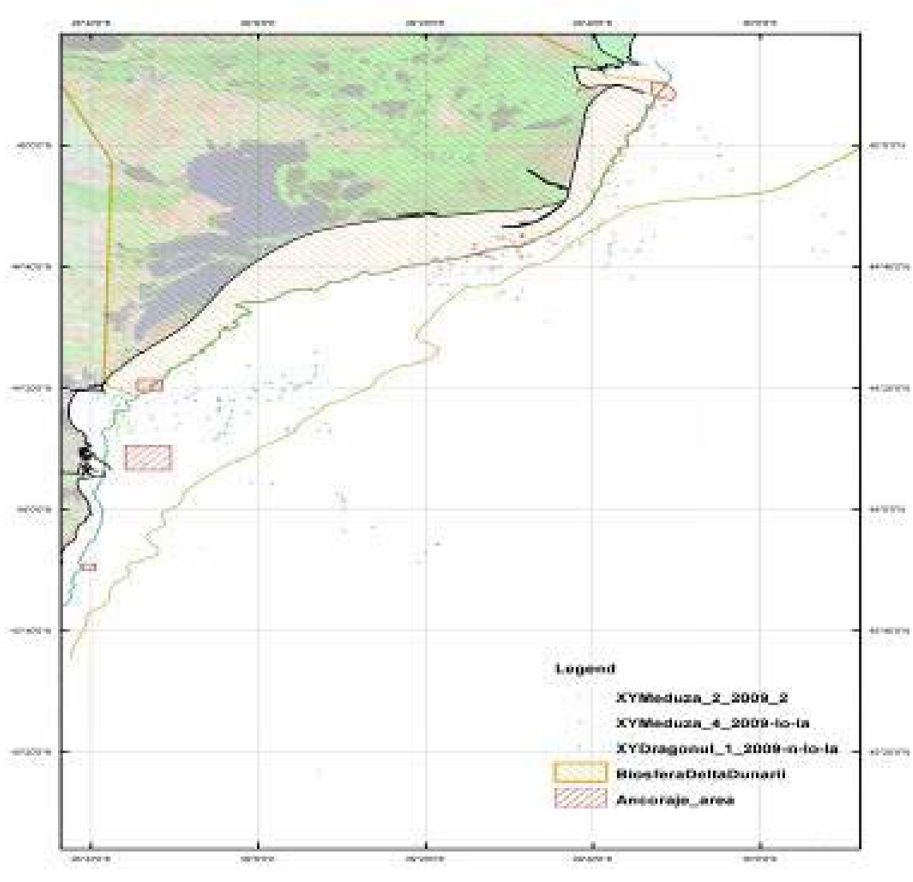


Fig. 4.1.4.4.4. Distribution of the activity of main trawlers in the Romanian marine area

4.1.5 Scientific Surveys

4.1.5.1 List of surveys conducted

Romanian sprat survey, spring 2009
The pelagic trawl survey took place in June. 36 trawl stations were realised with apelagic trawl - 50/35-74 at depth of 22m, average trawling speed (2.6 knots), time of trawling (1 hour). One random sample was taken at each trawl station and all fish species were recorded and measured. Catch per surveyed area was estimated using information horizontal opening of the trawl, trawling speed and time and then extrapolated to obtain the catch per unit area (CPUA) for each species.

Romanian sprat survey, autumn 2009
In the autumn period (October-November) 30 trawl stations were surveyed in Romanian waters. The survey protocol used was the same as for the spring survey.

Bulgarian sprat survey, spring 2009
Stratified sampling methodology (Sparre &Venema, 1998) was applied in Bulgarian waters (Raykov, 2008). Taking into account exact depths (isobaths), the whole area was divided to sub areas,. "strata", depending on depth: first stratum – 35- 50 m., second 50-75m, and third 75-100m. The examined area was divided into equal sized fields - with total number 55; each sector equal to about 63 кm2 (5' Lat. × 5' Long.). The trawling activities were carried out in meridian direction. The duration of each haul was 60 min; average velocity 2.8 knots (5.19 km/h).

Biological data collection using mid-water trawl supply scientists with valuable information of population parameters such as size, age, sex composition, condition (Fulton's coefficient).. Estimates of abundance, spatial distribution and migration are important source of information concerning population dynamics.

In the conditions of the Black Sea sprat forms aggregations in the bottom layer bellow the thermocline (sprat is cold-water species). The main fishing gear for the sprat fishery is mid-water trawl (OTM) – operating near the bottom. In the Black Sea and especially in North-Western part assessments based on trawl survey had been conducted for 30 years by Ukraine, from around 20 years by Romania and Bulgaria.

Sprat trawl survey is only a temporary solution, in future (starting 2011) hydro acoustic survey will be used to assess abundances indices data for tuning of age-structured models.

4.1.5.2 Geographical distribution patterns

During the Romanian pelagic survey in June 2009 the sprat catches obtained with pelagic trawl ranged between 0.13 t/Nm2 and 30 t/Nm2 . The surveyed area was about 2,606 Nm2 being divided in three areas which average values per unit area between 3.5 -18.2 t/Nm2 (Table 4.1.5.2.1). The densiest sprat schools were found in the northern part of the coast beyond of 30 m isobaths, and between Vadu and Constanta up to near 60 m isobaths. (Fig. 4.1.5.2.1).

Table 4.1.5.2.1 Assessment of the sprat biomass in Romanian waters using the swept area method with pelagic trawl (June 2009).

No. polygon		Range (t/Nm2)	Average (t/Nm2)	Total tons in polygon (t)	Notes
1	1,523	0.13 – 6.48	3.54	5391.4	Extrapolated at 33 683 tons for the shelf till 50 Nm from shore
2	648	2.82 – 20.80	11.73	7601.0	
3	434	3. 24 – 30.00	18.20	7899.0	
Total				20891.4	

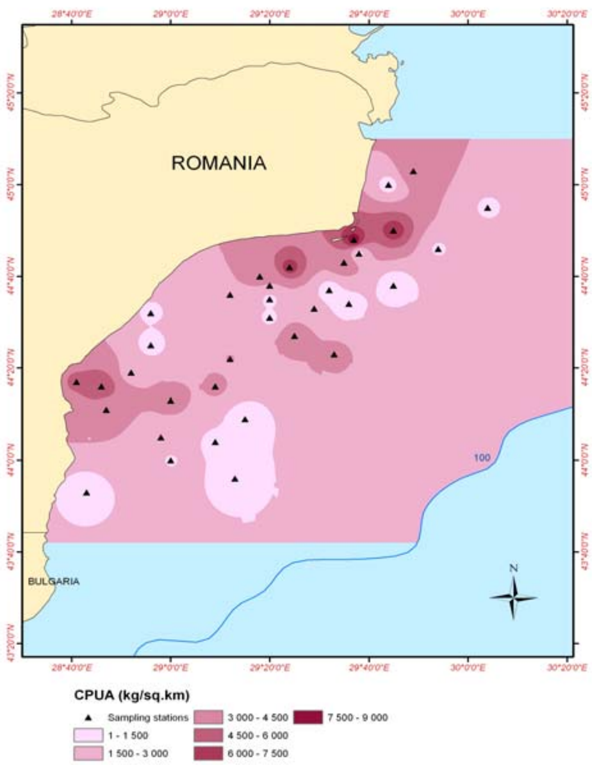


Figure 4.1.5.2.1 The distribution of the sprat in Romanian water in June 2009, pelagic trawl survey

In the autumn period (October – November), the sprat survey catches ranged between 0.26 – 41.73 t/Nm2 or 2.05 t/Nm2 to 21.93 t/Nm2 average (Tab. 4.1.5.2.2). The sprat was spread on entire shelf but bigger concentration was found between Gura Portitei and Cap Tuzla (Fig. 4.1.5.1.2.), from the shore to the beyond 30m isobaths.

Table 4.1.5.2.2. Assessment of the sprat biomass in Romanian waters using the swept area method with pelagic trawl (October -November 2009)

No. polygon	Surveyed area (Nm2)	Range (t/Nm2)	Average (t/Nm2)	Total tons in polygon (t)	Notes
1	239.13	0.26 - 4.37	2.05	490.22	Extrapolated at 60 075 tons for the shelf till 50 Nm from shore
2	191.00	9.07 – 18.11	13.28	2536.48	
3	116.50	1.23 – 4.89	2.72	316.88	
4	862.50	7.13 – 41.73	21.93	18914.63	
5	673.38	5.31 – 19. 47	11.17	7521.65	
Total	2,082.51			29780	

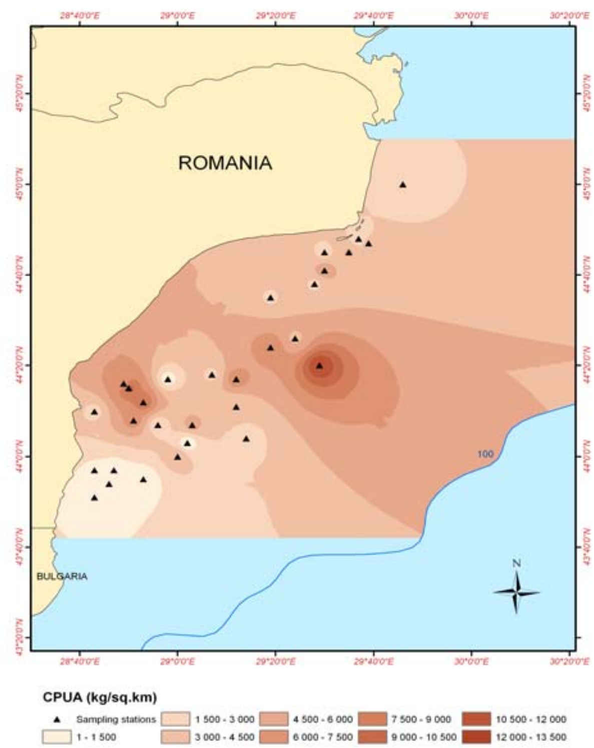


Figure 4.1.5.2.2. The distribution of sprat in Romanian waters in October 2009, pelagic trawl survey

Bulgarian spring pelagic trawl survey was carried out on 36 fields in the period 4-28 May 2009. 19 fields were examined in depth from 30-50 (I stratum), 9 fields were examined in depth from 50 to 75 m and eight for 75-100 m. The trawling velocity was from 5 to 5.56 km/h. Stock assessment by “swept area” method was carried out in the corresponding area in 3 different strata (Raykov et al., 2009). The estimated biomass was 41 761 t (Tab. 4.1.5.2.3).

Table 4.1.5.2.3. Assessment of the sprat biomass in Bulgarian waters using the swept area method with pelagic trawl (May 2009).

CPUA mean		**B (kg)**	**Ax**	**№ Fields**
9696.306	30-50	17597.050	1814.82	29
1593.405	50-75	4387.473	2753.52	44
7900.637	75-100	19776.875	2503.20	40
		41761.398	7071.54	**113**

High levels of CPUA of sprat were found near the shore, at stratum I (Fig. 4.1.5.2.3). Mean CPUA at stratum I was 9696 kg/km^2 (Fig. 4.1.5.2.3 , Tab. 4.1.5.2.3) .At stratums III CPUA was lower: 7900 kg/km^2 .

No larva and juvenile surveys have been carried out in Black Sea during 2009.

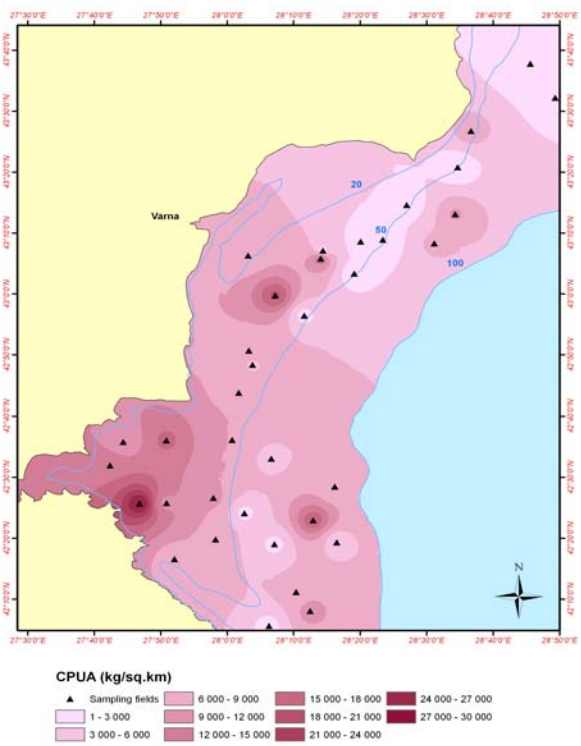


Figure 4.1.5.2.3. The distribution of sprat in Bulgarian waters May 2009

4.1.5.3 Trends in abundance at length or age

The biomass indexes of Romanian and Bulgarian pelagic trawl surveys are presented on Fig. 4.1.5.3.1. The trends show that Bulgarian biomass indexes increased toward 2009 and Romanian slightly decreased after 2008.

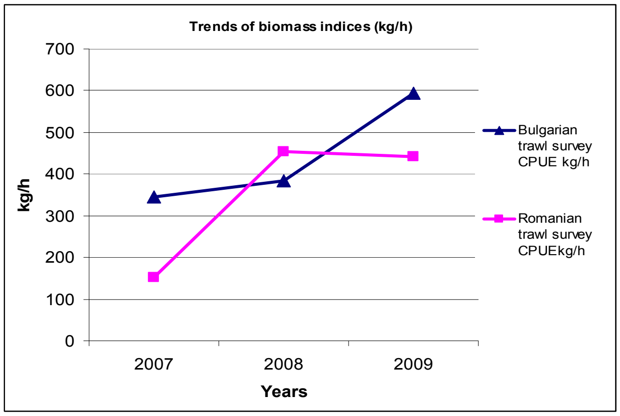
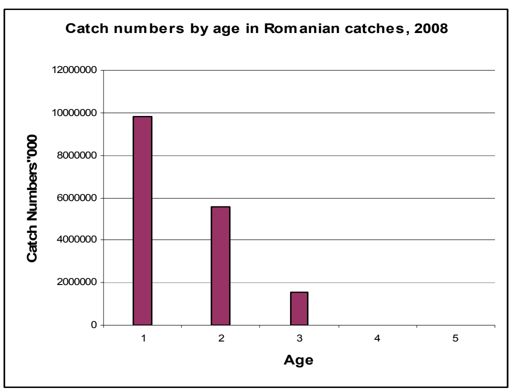
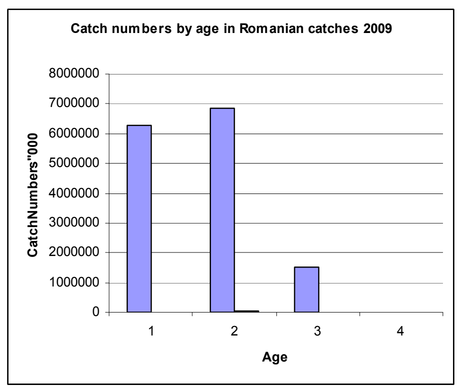
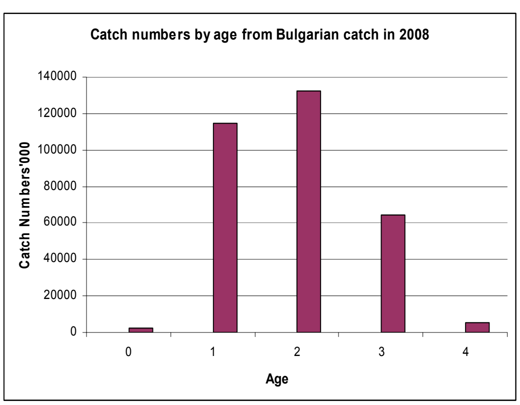


Figure 4.1.5.3.1. Trends in abundance (CPUE kg.h^{-1}) derived from Bulgarian and Romanian pelagic trawl surveys.

Catch numbers by age (Fig. 5.1.5.3.1a, b, c, d) from surveys in Romania and Bulgaria show similar trends. Prevailing age classes were 1-1+ and 2-2+, as the age class 3-3+ was significantly well presented in Bulgarian waters in comparison with Romanian trawl surveys results.

a. 

b. 

c. 

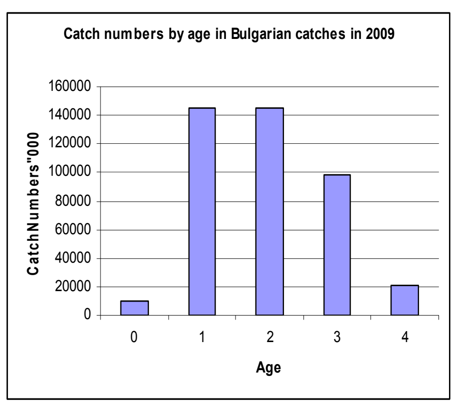
d. 

Figure 4.1.5.3.1a-d. Trends in abundance by age from surveys in Romania (a, b) and Bulgaria (c, d).

Commercial catch in Bulgaria comprised by 1-1+ and 2-2+ old species mainly. The similar trend in scientific surveys has been observed. Samples collected from Turkish bottom trawls operating in deeper waters (60-85m) also confirm the tendency that larger/older fish (Age 3 and 4) is distributed in deeper waters (Fig. 4.1.5.3.2).

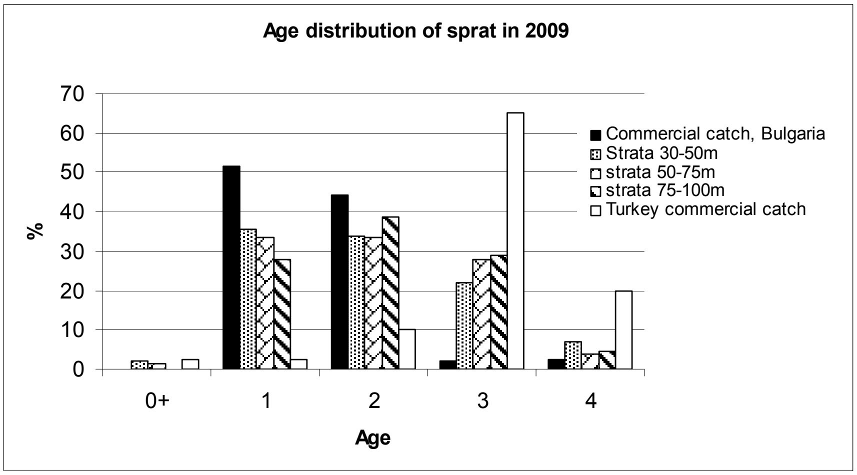


Figure 4.1.5.3.2. Age composition of commercial and survey catches of sprat showing lower selectivity of larger/older fish by the Bulgarian commercial fleet and at lower dept.

4.1.5.4 Trends in growth

Length has bimodal distribution in terms of (85-90mm) and (90-95mm). Sub dominated are the ranges 80-85 and 95-100mm.

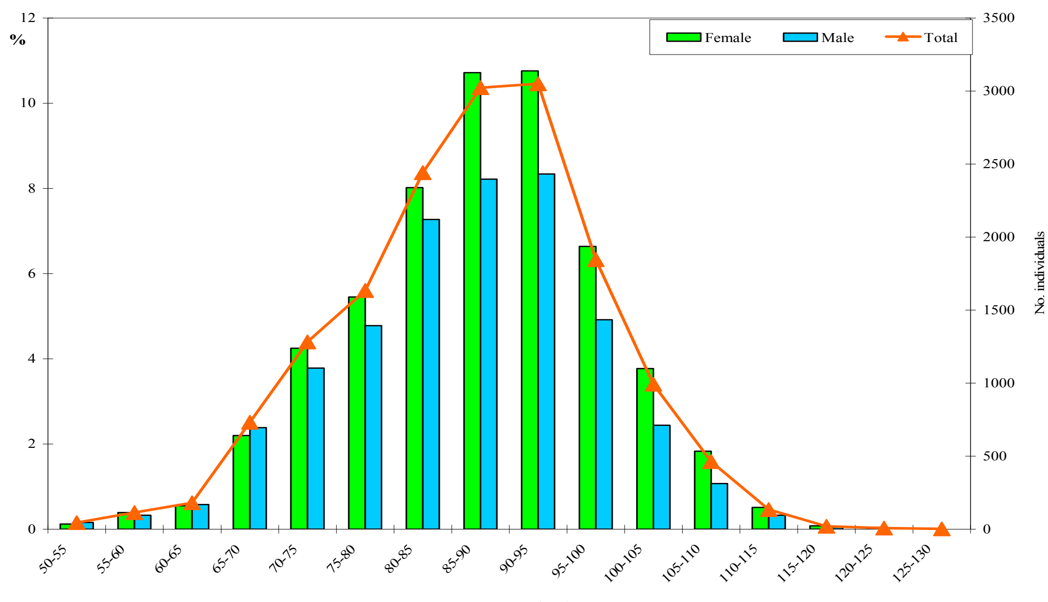


Figure 4.1.5.4.1. Sprat length dynamics in the western part of the Black Sea

4.1.5.5 Trends in maturity

No analyses were conducted in 2009.

4.1.6 Assessment of historic parameters

4.1.6.1 Justfication

We used Integrated Catch-at-age Analysis (ICA; Patterson and Melvin, 1996). ICA is a statistical catch-at-age method based on the Fournier and Deriso models (Deriso et al., 1985). It applies a statistical optimization procedure to calculate population numbers and fishing mortality coefficients-at-age from data of catch numbers-at-age and natural mortality. The dynamics of a cohort (generation) in the stock are expressed by two non-linear equations referred to as a survival equation (exponential decay) and a catch equation:

$$N_{a+1,y+1} = N_{a,y} * exp(-F_{a,y} - M),$$
$$C_{a,y} = N_{a,y} * [1 - exp(-F_{a,y} - M)] * F_{a,y} / (F_{a,y} + M),$$

where C, N, M, and F are catch, abundance, natural mortality, and fishing mortality, respectively, and a and y are subscript indices for age and year.
The algorithm initially estimates population numbers and fishing mortality fitting a separable model, when F is assumed to conform to a constant selection pattern (fishing mortality-at-age), but fishing mortality by year is allowed to vary. The F matrix is then modelled as a multiplication of the year-specific F and the specified selection pattern. This procedure substantially diminishes the number of parameters in the model.
In its second stage, the ICA algorithm minimizes the weighted Sum of Square Residuals (SSR) of observed and modelled catch and relative abundance indices (CPUE), assuming Gaussian distribution of the log residuals:

$$min \, [\sum_{a,y} pc_{a,y} (log \, C_{a,y} - log \, \hat{C}_{a,y})^2 + \sum_{a,y,f} pi_{a,f} (log \, I_{a,y,f} - log \, \hat{I}_{a,y,f})^2,$$

where C, Ĉ, I, and Î are observed and estimated catch and age-structured index, respectively, and a, y, and f are subscript indices for age, year, and fleet, respectively. Weights associated with catches and different indices (pc, pi) are ideally set equal to the inverse variances of catch and index data, and can be calculated based on the residuals between modelled and observed values. However, weights are usually set by the user on the basis of some information about the reliability of different indices and current experience with modelling the stock. Indices are defined as related to population numbers by the equations:

$$\hat{I}_{a,y} = N_{a,y} * exp(-F_{a,y} - M)$$
$$\hat{I}_{a,y} = q_a * N_{a,y} * exp(-F_{a,y} - M)$$
$$\hat{I}_{a,y} = q_a * (N_{a,y} * exp(-F_{a,y} - M))^{k}{}_{a} .$$

The two unknown parameters (qa, an age-specific catchability, and k, a constant) are estimated according to the assumed relationship between the population and the abundance index, which has to be specified as being one of the above – identity, linear, or power, respectively.
ICA combines the power and accuracy of a statistical model with the flexibility of setting different options of the parameters (e.g. a separable model accounting for age effects) and for this raison is suitable for a short living species (age 5 at maximum) such as the Black Sea sprat. ICA has previously been

successfully applied to sprat by Daskalov (1998), Daskalov et al. (2008), and Daskalov & Mamedov (2007).

4.1.6.2 Input parameters

Catch and weight at age, natural mortality, and 3 age structured indices are used to run ICA (Table 4.1.6.2.1). New data from Ukrainian and Turkish sprat fisheries were added to the input catch-at-age matrix that improved the data quality and consistency of the analyses. The e timing of the meeting of the STECF SG Black Sea was convenient in order to have official (and most reliable) fisheries information from Turkey, which has been a problem last year, because the meeting has been scheduled in June.
Adult stock indices are derived from commercial CPUE of Bulgarian and Ukrainian trawling fleets and an index of juvenile fish (age 0.5 in July) is obtained from Romanian juvenile survey.

Table 4.1.6.2.1. Sprat input parameters.

Output Generated by ICA Version 1.4

SPRAT 2009

Catch in Number

AGE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	640.	492.	51.	255.	115.	21.	108.	278.	236.	1009.	406.	809.	415.	1202.	445.
1	5236.	8047.	2673.	2673.	2072.	1712.	2496.	2741.	2278.	3838.	4877.	10352.	6829.	5654.	6878.
2	3093.	1363.	2114.	1453.	2182.	2792.	2773.	2600.	2831.	3086.	3340.	6646.	7655.	5454.	3580.
3	2322.	106.	528.	218.	442.	418.	579.	830.	1741.	1302.	1313.	1269.	3090.	3024.	2666.
4	359.	55.	96.	14.	13.	13.	17.	43.	82.	121.	110.	109.	182.	674.	278.
5	0.	0.	7.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

x 10 ^ 6

Catch in Number

AGE	2005	2006	2007	2008	2009
0	528.	1158.	3180.	1299.	1558.
1	6024.	5976.	5351.	7774.	12266.
2	4652.	2705.	1876.	3248.	7833.
3	1602.	785.	802.	1327.	3278.
4	372.	92.	113.	168.	369.
5	0.	0.	0.	0.	0.

x 10 ^ 6

Predicted Catch in Number

AGE	2002	2003	2004	2005	2006	2007	2008	2009
0	790.7	948.6	837.5	1259.1	1139.1	1165.1	524.3	1558.3
1	7630.4	6728.6	5357.1	6949.5	5474.8	5721.2	8498.1	7038.6
2	5669.6	6068.2	3449.1	3960.0	2657.1	2594.0	3996.3	9777.9
3	2899.7	2870.8	1913.5	1538.6	896.9	809.3	1185.6	2674.8
4	166.6	542.8	313.1	311.5	113.7	94.8	134.9	313.1

x 10 ^ 6

Weights at age in the catches (Kg)

AGE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	.001500	.001500	.001700	.001700	.002300	.002500	.002500	.002300	.002400	.002800	.002300	.001700	.001800	.001700	.001900
1	.003000	.002100	.002100	.002500	.003400	.003800	.003800	.003300	.004000	.003200	.003500	.002500	.002700	.002800	.002900
2	.005800	.004400	.004500	.003600	.004000	.004600	.005200	.004900	.005100	.005000	.004500	.004000	.004100	.004000	.004400
3	.006900	.007100	.006800	.006000	.004700	.005400	.006000	.006300	.007600	.006500	.006000	.006300	.005800	.006100	.006000
4	.009100	.009400	.008600	.007700	.007700	.006900	.007400	.007200	.009400	.007300	.007800	.006900	.007700	.006800	.007300
5	.010900	.010800	.010800	.010800	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000

Weights at age in the catches (Kg)

AGE	2005	2006	2007	2008	2009
0	.002100	.002000	.001700	.002300	.002400
1	.003500	.003300	.003300	.003400	.003100
2	.004700	.004300	.004900	.004300	.004000
3	.006200	.006000	.007200	.005200	.004900
4	.007700	.007300	.008700	.007000	.006000
5	.010000	.010000	.010000	.010000	.000000

Weights at age in the stock (Kg)

AGE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	.001500	.001500	.001700	.001700	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000
1	.003000	.002100	.002100	.002500	.003500	.003300	.002800	.002700	.003400	.002500	.003200	.003500	.003600	.003500	.003400
2	.005800	.004400	.004500	.003600	.004100	.004300	.004300	.004700	.004600	.004700	.004400	.004400	.004500	.004400	.004400
3	.006900	.007100	.006800	.006000	.004800	.004800	.004700	.005700	.006400	.005900	.005600	.005200	.006100	.005900	.006000
4	.009100	.009400	.008600	.007700	.006200	.005500	.005300	.006900	.008200	.007300	.007200	.006700	.007400	.007400	.007200
5	.010900	.010800	.010800	.010800	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000

Weights at age in the stock (Kg)

AGE	2005	2006	2007	2008	2009
0	.001000	.001000	.001000	.001000	.001000
1	.003600	.003600	.003600	.003100	.003100
2	.004600	.004600	.004700	.004200	.004100

AGE					
3	.006100	.005700	.006300	.005600	.004700
4	.007400	.007400	.007600	.007000	.005400
5	.010000	.010000	.010000	.010000	.000000

Natural Mortality (per year)

AGE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000
1	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
2	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
3	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
4	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
5	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000

Natural Mortality (per year)

AGE	2005	2006	2007	2008	2009
0	0.64000	0.64000	0.64000	0.64000	0.64000
1	0.95000	0.95000	0.95000	0.95000	0.95000
2	0.95000	0.95000	0.95000	0.95000	0.95000
3	0.95000	0.95000	0.95000	0.95000	0.95000
4	0.95000	0.95000	0.95000	0.95000	0.95000
5	0.95000	0.95000	0.95000	0.95000	0.95000

Proportion of fish spawning

AGE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	2005	2006	2007	2008	2009
0	0.0000	0.0000	0.0000	0.0000	0.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000

AGE-STRUCTURED INDICES

Bul

AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	9.78	19.59	41.06	53.32	52.36	101.06	96.51	87.64	69.14	73.95	80.74	58.86	73.12	65.32	77.50
2	57.49	48.77	38.16	28.37	58.52	30.60	68.95	60.47	66.09	64.79	54.65	38.78	38.98	37.62	70.25
3	16.27	7.36	9.45	6.21	5.28	4.54	6.28	3.43	21.45	18.67	19.65	13.08	7.58	11.60	50.73
4	0.25	0.23	0.59	0.61	0.54	0.30	0.61	0.20	1.16	3.34	4.85	1.31	2.35	1.98	5.04

x 10 ^ 3

Bul

AGE	2009
1	125.36
2	109.76
3	37.33
4	5.98

x 10 ^ 3

Ukr

AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	124.38	80.94	111.12	58.09	59.67	97.40	222.49	193.27	158.30	76.22	125.47	113.57	180.31	127.15	284.84
2	74.90	103.68	118.27	50.40	68.14	85.43	146.35	118.28	179.30	76.02	46.40	88.14	69.18	24.19	55.49
3	8.05	9.43	9.43	10.52	46.52	37.49	66.40	22.53	76.56	47.52	54.76	29.98	24.67	16.90	37.53

```
  4   |    0.51    0.14    0.66    0.72    2.36    0.56    6.10    2.15    4.65   10.87    5.06    8.06    2.52    0.10    3.07
------+------------------------------------------------------------------------------------------------------------------------
       x 10 ^ 3


        Ukr
        ---
------+--------
AGE   |    2009
------+--------
  1   |  335.38
  2   |  143.30
  3   |   37.47
  4   |    0.66
------+--------
       x 10 ^ 3


        RI
        --
------+------------------------------------------------------------------------------------------------------
AGE   |    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005    2006    2007    2008
------+------------------------------------------------------------------------------------------------------
  0   |  3727.0   320.0  1349.0 *******  1600.0  6300.0  2186.0 ******* *******  1475.0 *******  1213.0   127.0
------+------------------------------------------------------------------------------------------------------
```

4.1.6.3 Results

ICA was run assuming a constant selection pattern in 2002-2009 (Fig. 4.1.6.3.2, Table 4.1.6.3.1) with reference F at age 2 and Selection at the last 'real' age (S4) equal 1.

The results of the ICA show a reasonable agreement with tuning data (Fig. 4.1.6.3.3. Fig. 4.1.6.3.4. Fig. 4.1.6.3.5) except for recruitment *vs* Romanian young fish survey. The overall fit and partial SSR converged to unique minima (Fig. 1.5.3.1) again with the exception of the Romanian young fish survey. The fit is particularly good for Ukrainian CPUE data that corresponds to the dominant pattern in age composition driven by Ukrainian catches which dominate the total catch.

Shrinking of the terminal Fs in the last year was applied using the last 5 years of the originally estimated F matrix (Table 4.1.6.3.1.).

The analysis of the main population parameters (abundance, catch, fishing mortality, Fig. 4.1.6.3.6. Table 4.1.6.3.1.) shows that the sprat stock has recovered from the depression in the 1990s due to good recruitment in 1999-2001 and the biomass and catches have gradually increased over the 1990s and during the 2000s reached levels comparable to the previous period of high abundance 1975-1989 (Fig. 4.1.6.3.8). The stock estimates reveal the cyclic nature the sprat population dynamics. The year with relatively strong recruitment were followed by years of low to medium recruitment which leads to a relative decrease of the Spawning Stock Biomass (SSB). High fishing mortalities ($F_{1\text{-}3}$) were observed during the stock collapse in the early 1990s, in 2005, and 2009 when catches reached the third highest level due to the intensive development of the Turkish sprat fishery.

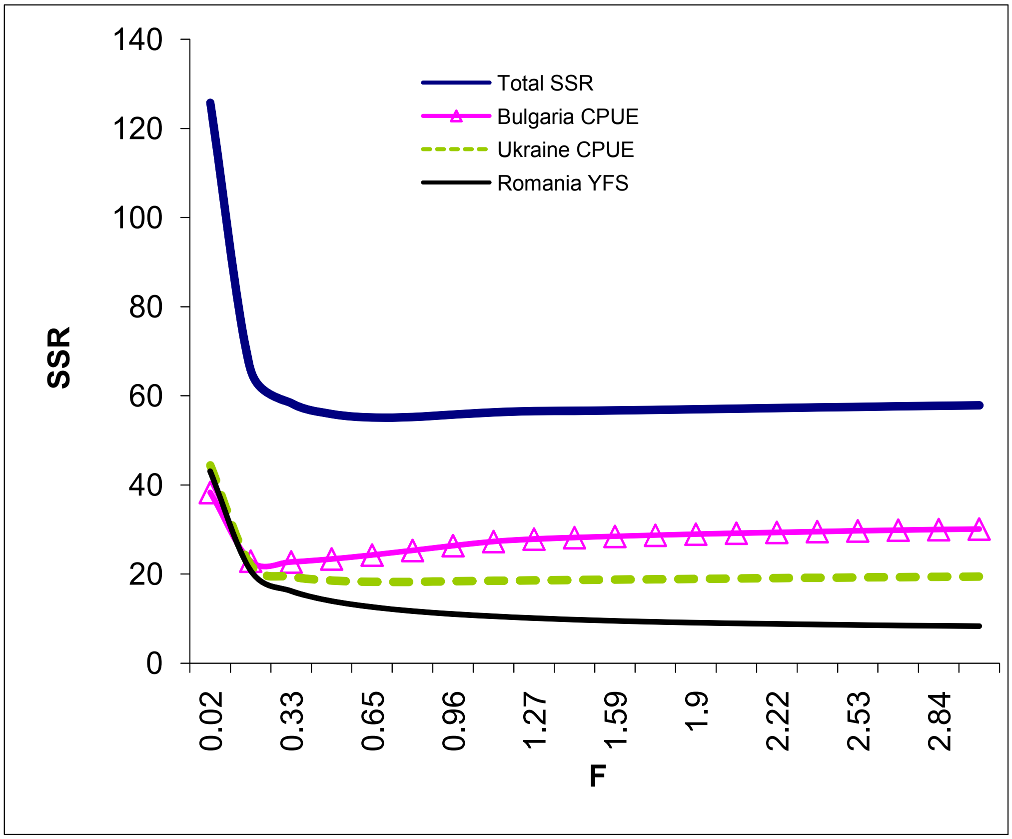


Fig. 4.1.6.3.1. Trajectories of the total Sum of Squared Residuals (SSR) and the partial SSRs of the two tuning fleets as functions of the reference F.

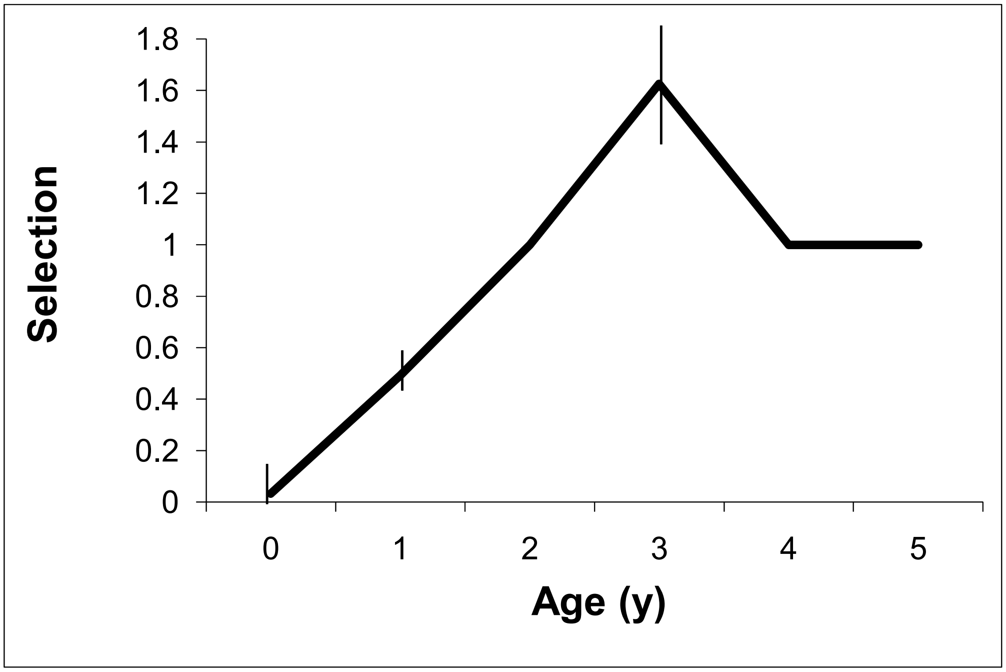


Fig. 4.1.6.3.2. Selection pattern estimated by the separable model

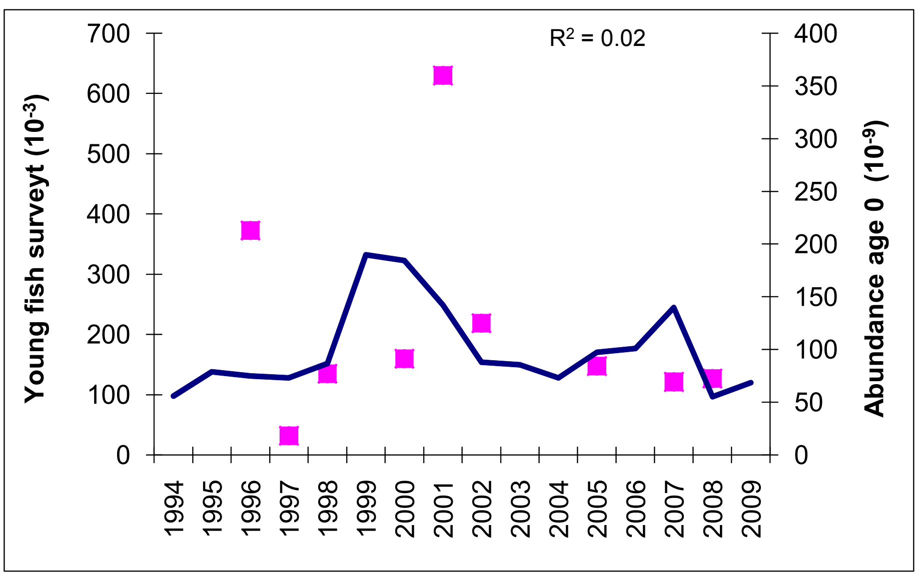


Fig. 4.1.6.3.3. Adjustment of ICA: (a) time-series of estimated recruitment (line) and young fish research survey index (diamonds), (b) scatterplot of survey vs. recruitment estimates (diamonds) and best fit (line) given by a power relationship (the equation and r^2 are shown).

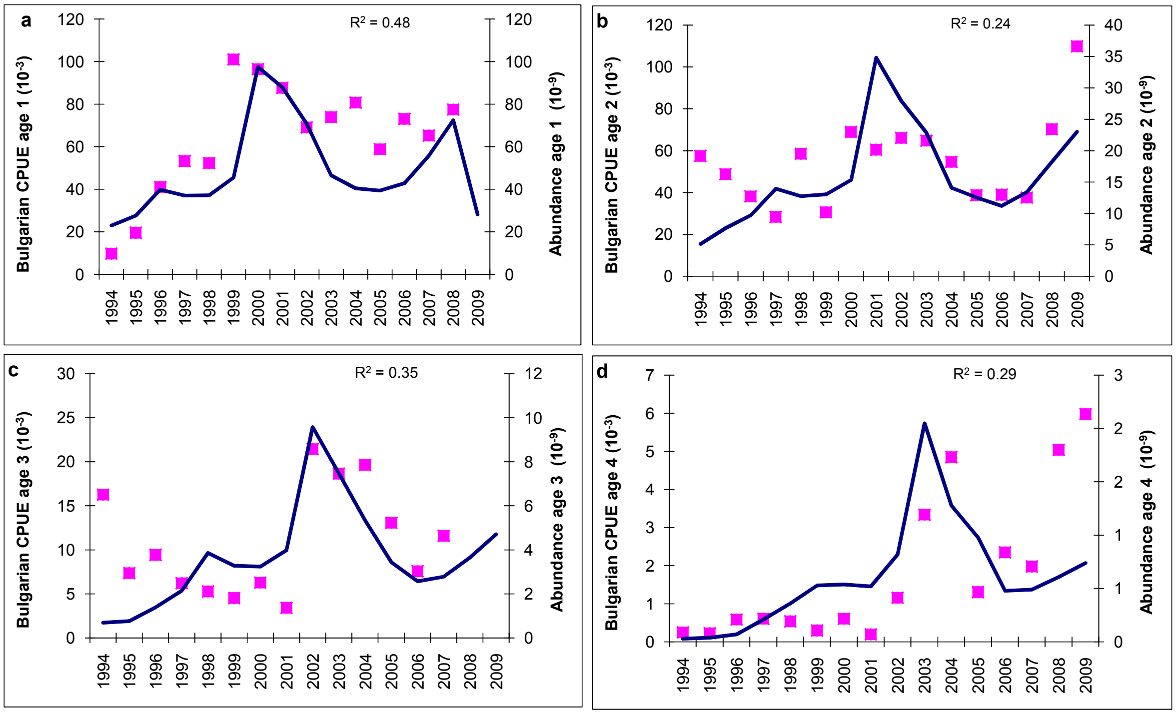


Fig. 4.1.6.3.4. Adjustment of ICA: time-series of estimated abundance-at-age and age-structured research survey indices (best fit is given by linear relationships and r^2 are displayed): (a) Age 2, (b) Age 3, (c) Age 4, (d) Age 5.

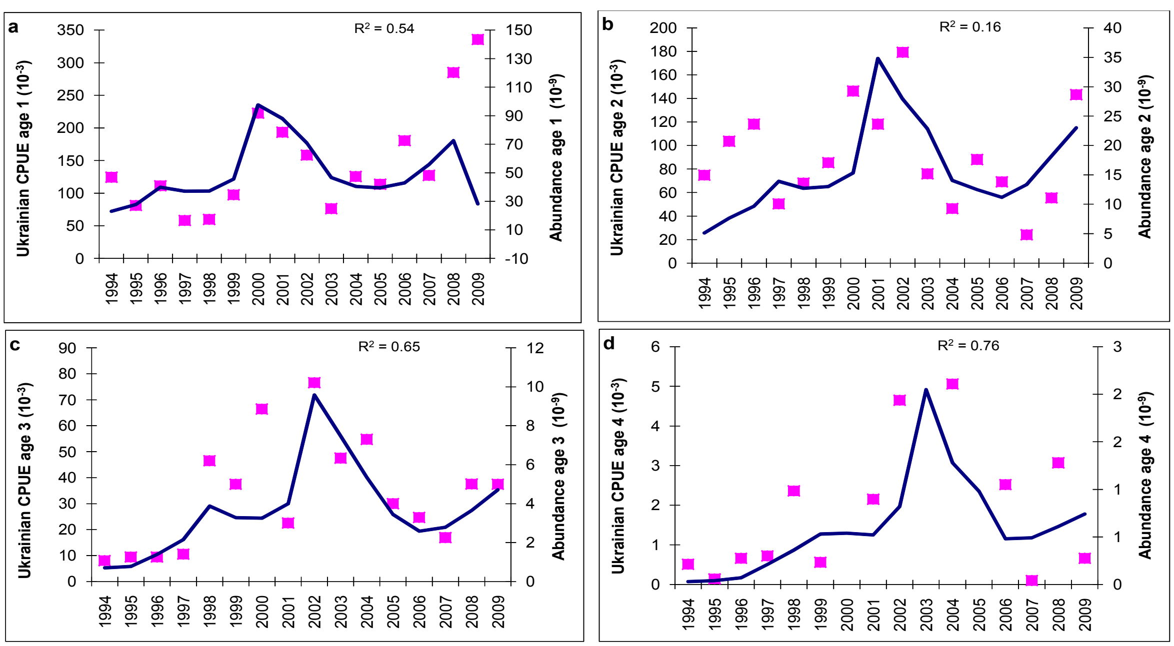


Figure 4.1.6.3.5. Adjustment of ICA: time-series of estimated abundance-at-age and age-structured research survey indices (best fit is given by linear relationships and r^2 are displayed): (a) Age 2, (b) Age 3, (c) Age 4, (d) Age 5.

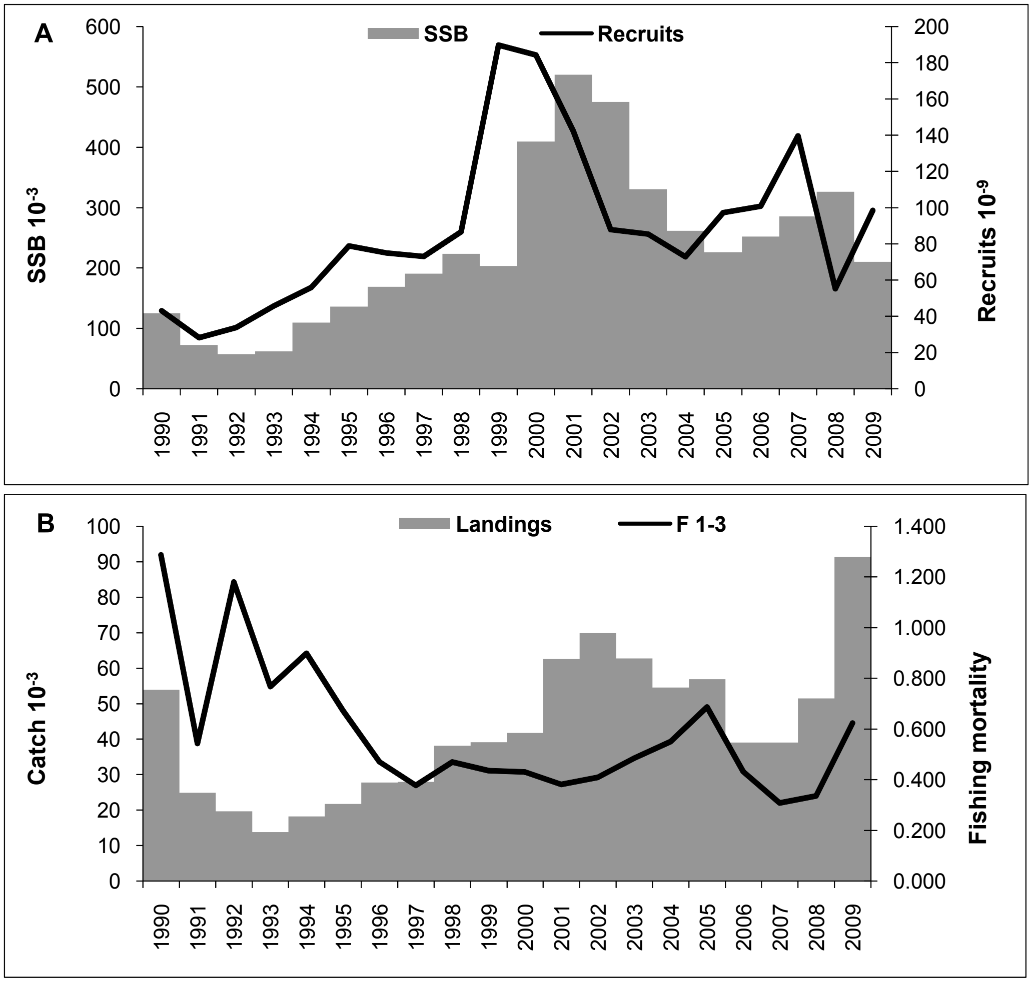


Fig. 4.1.6.3.6. Time-series of sprat population estimates: A. recruitment (line) and SSB (grey); B. landings (grey) and average fishing mortality (ages 2–4, line).

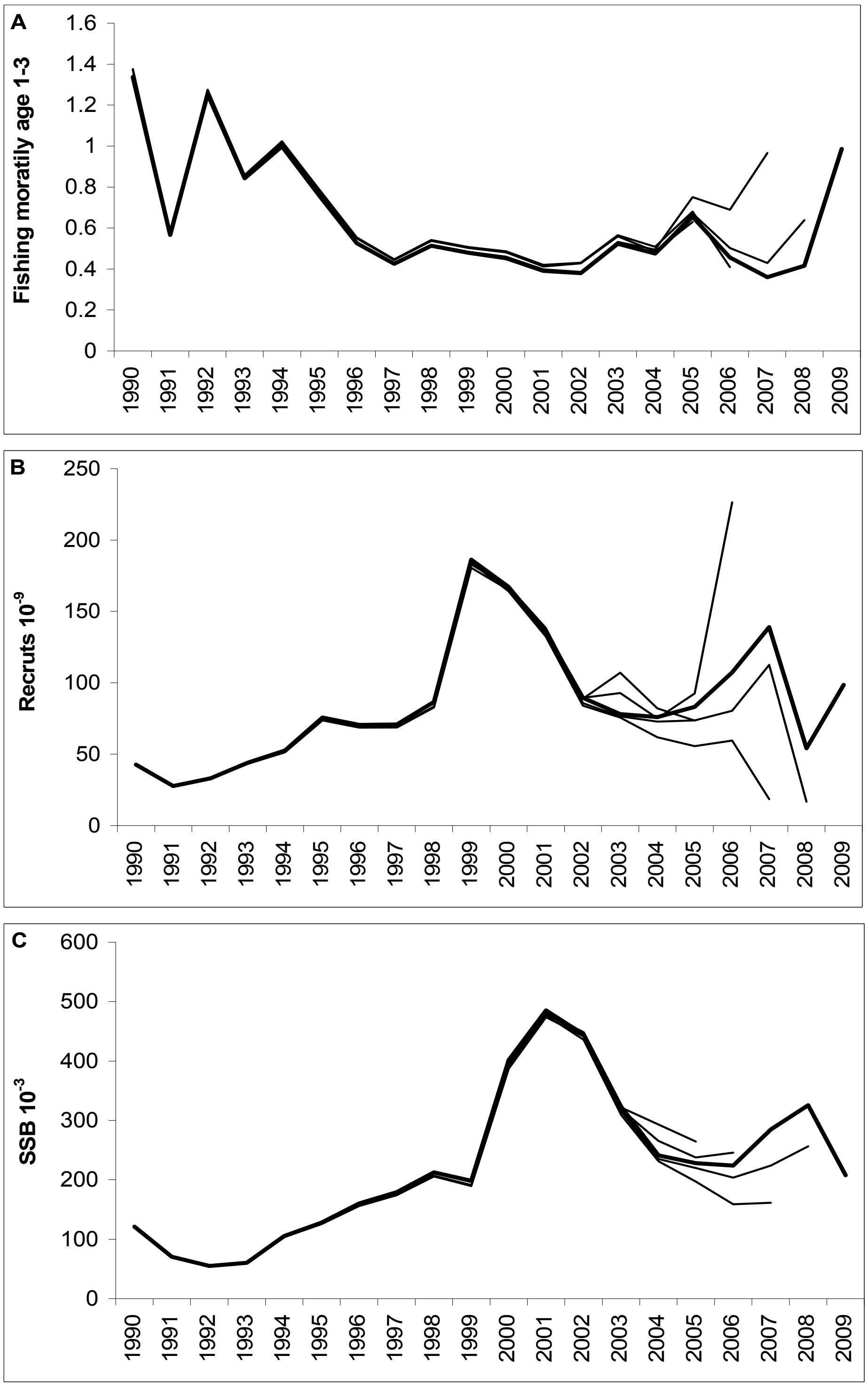


Fig. 4.1.6.3.7. Retrospective analyses of ICA on sprat

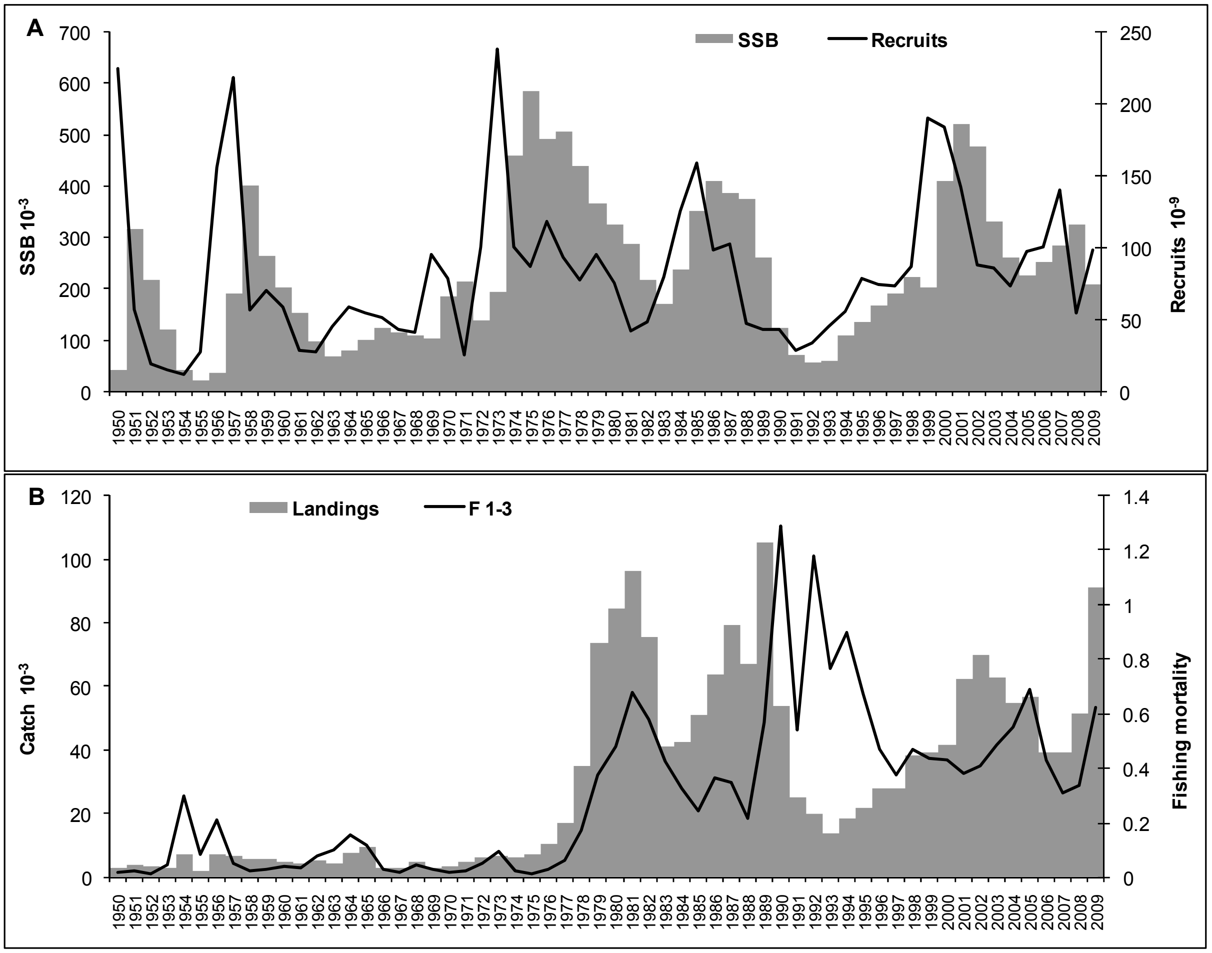


Fig. 4.1.6.3.8. Time-series of sprat population estimates – present results combined with historical estimates from Daskalov 1998a: A. recruitment (line) and SSB (grey); B. landings (grey) and average fishing mortality (ages 2–4, line).

Table 4.1.6.3.1. Sprat in the Black Sea 1990-2009: ICA results and diagnostics.

Fishing Mortality (per year)

AGE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	0.0205	0.0243	0.0021	0.0079	0.0030	0.0004	0.0021	0.0053	0.0037	0.0074	0.0033	0.0081	0.0120	0.0166	0.0150
1	0.5497	0.7629	0.3337	0.2663	0.1484	0.1000	0.1012	0.1203	0.0989	0.1383	0.0801	0.1981	0.1799	0.2477	0.2248
2	1.2375	0.6709	1.3666	0.7736	0.9470	0.7595	0.5545	0.3310	0.4063	0.4382	0.3963	0.3399	0.3656	0.5033	0.4568
3	2.2204	0.2657	2.0603	1.4864	1.9020	1.4125	0.9232	0.8254	1.0350	0.8594	0.8811	0.6334	0.5942	0.8180	0.7424
4	1.2402	0.7948	1.1041	0.7431	0.8063	0.6107	0.4427	0.3611	0.4147	0.4160	0.3671	0.3773	0.3656	0.5033	0.4568
5	1.2402	0.7948	1.1041	0.7431	0.8063	0.6107	0.4427	0.3611	0.4147	0.4160	0.3671	0.3773	0.3656	0.5033	0.4568

Fishing Mortality (per year)

AGE	2005	2006	2007	2008	2009
0	0.0207	0.0145	0.0114	0.0132	0.0312
1	0.3099	0.2163	0.1706	0.1971	0.4671
2	0.6297	0.4395	0.3466	0.4006	0.9492
3	1.0234	0.7143	0.5633	0.6510	1.5426
4	0.6297	0.4395	0.3466	0.4006	0.9492
5	0.6297	0.4395	0.3466	0.4006	0.9492

Population Abundance (1 January)

AGE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	42.67	27.64	32.97	43.98	52.57	75.63	70.53	70.89	86.69	186.28	167.23	135.34	89.45	78.11	75.93
1	18.39	22.04	14.22	17.35	23.01	27.64	39.86	37.11	37.18	45.54	97.50	87.89	70.79	46.60	40.51
2	6.16	4.10	3.97	3.94	5.14	7.67	9.67	13.93	12.73	13.03	15.34	34.80	27.88	22.87	14.07
3	3.46	0.69	0.81	0.39	0.70	0.77	1.39	2.15	3.87	3.28	3.25	3.99	9.58	7.48	5.35
4	0.71	0.15	0.20	0.04	0.03	0.04	0.07	0.21	0.36	0.53	0.54	0.52	0.82	2.05	1.28
5	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

x 10 ^ 9

Population Abundance (1 January)

AGE	2005	2006	2007	2008	2009	2010
0	83.02	107.31	138.99	54.16	68.48	97.59
1	39.44	42.88	55.77	72.46	28.18	35.00
2	12.51	11.19	13.36	18.19	23.01	6.83
3	3.45	2.58	2.79	3.65	4.71	3.44
4	0.98	0.48	0.49	0.61	0.74	0.39
5	0.00	0.00	0.00	0.00	0.00	0.11

x 10 ^ 9

Weighting factors for the catches in number

AGE	2002	2003	2004	2005	2006	2007	2008	2009
0	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Predicted Age-Structured Index Values

Bul Predicted

AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	30.31	37.30	53.77	49.58	50.21	60.30	132.91	112.94	91.79	58.42	51.36	47.93	54.60	72.66	93.15
2	14.81	24.27	33.90	54.61	48.04	48.39	58.19	135.82	107.43	82.24	51.78	42.24	41.54	51.95	68.85
3	1.63	2.28	5.24	8.52	13.82	12.78	12.53	17.42	42.64	29.77	22.10	12.37	10.80	12.60	15.80
4	0.08	0.10	0.20	0.60	1.00	1.45	1.51	1.45	2.30	5.36	3.42	2.42	1.29	1.38	1.69

x 10 ^ 3

Bul Predicted

AGE	2009
1	31.66
2	66.21
3	13.05
4	1.54

x 10 ^ 3

Ukr Predicted

AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008

AGE															
1	66.51	81.85	117.98	108.80	110.17	132.32	291.64	247.84	201.42	128.18	112.71	105.16	119.80	159.43	204.41
2	23.38	38.31	53.52	86.21	75.84	76.39	91.87	214.41	169.58	129.82	81.75	66.68	65.57	82.00	108.68
3	3.88	5.44	12.50	20.32	32.97	30.49	29.90	41.56	101.76	71.04	52.72	29.52	25.78	30.07	37.70
4	0.11	0.15	0.29	0.88	1.46	2.13	2.20	2.12	3.36	7.83	5.01	3.54	1.89	2.02	2.47

x 10 ^ 3

Ukr Predicted

AGE	2009
1	69.47
2	104.52
3	31.14
4	2.26

x 10 ^ 3

RI Predicted

AGE	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	953.9	957.2	1171.5	*******	2260.4	1824.8	1203.7	*******	*******	1112.3	*******	1871.0	728.4

Fitted Selection Pattern

AGE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	0.0166	0.0363	0.0015	0.0102	0.0031	0.0005	0.0037	0.0161	0.0091	0.0168	0.0083	0.0239	0.0329	0.0329	0.0329
1	0.4442	1.1371	0.2442	0.3443	0.1567	0.1317	0.1825	0.3635	0.2434	0.3156	0.2022	0.5827	0.4922	0.4922	0.4922
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.7942	0.3960	1.5076	1.9214	2.0084	1.8597	1.6650	2.4936	2.5471	1.9612	2.2235	1.8634	1.6252	1.6252	1.6252
4	1.0022	1.1847	0.8079	0.9606	0.8514	0.8040	0.7984	1.0910	1.0206	0.9493	0.9263	1.1102	1.0000	1.0000	1.0000
5	1.0022	1.1847	0.8079	0.9606	0.8514	0.8040	0.7984	1.0910	1.0206	0.9493	0.9263	1.1102	1.0000	1.0000	1.0000

Fitted Selection Pattern

AGE	2005	2006	2007	2008	2009
0	0.0329	0.0329	0.0329	0.0329	0.0329
1	0.4922	0.4922	0.4922	0.4922	0.4922
2	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.6252	1.6252	1.6252	1.6252	1.6252
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000

STOCK SUMMARY

Year	Recruits Age 0 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield /SSB ratio	Mean F Ages 1- 3	SoP (%)
1990	42666930	185266	121266	53900	0.4445	1.287	99
1991	27639990	112077	70617	24900	0.3526	0.542	99
1992	32973820	111245	55189	19700	0.3570	1.180	100
1993	43981190	134990	60222	13800	0.2292	0.767	100
1994	52572340	157783	105211	18219	0.1732	0.898	99
1995	75626210	203761	128135	21746	0.1697	0.672	100
1996	70533080	230657	160124	27778	0.1735	0.470	99
1997	70893040	250303	179410	27963	0.1559	0.377	100
1998	86692390	299408	212715	38117	0.1792	0.470	99
1999	186280220	384584	198304	39152	0.1974	0.435	98
2000	167234940	568804	401569	41769	0.1040	0.431	100
2001	135340160	620348	485008	62587	0.1290	0.381	100
2002	89448990	534269	444820	69894	0.1571	0.409	99
2003	78105630	401110	323004	62716	0.1942	0.485	99
2004	75930360	316829	240898	54574	0.2265	0.551	100
2005	83015620	310857	227841	56854	0.2495	0.686	100
2006	107305200	331361	224056	39048	0.1743	0.432	100
2007	138990500	423806	284816	39008	0.1370	0.308	99
2008	54160060	379907	325747	51463	0.1580	0.336	99
2009	98570000	276308	207827	91376	0.4397	0.623	100

No of years for separable analysis : 8
Age range in the analysis : 0 . . . 5
Year range in the analysis : 1990 . . . 2009
Number of indices of SSB : 0
Number of age-structured indices : 3

Parameters to estimate : 32
Number of observations : 177

Conventional single selection vector model to be fitted.

PARAMETER ESTIMATES

Parm. No.		Maximum Likelh. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
Separable model : F by year								
1	2002	0.3656	26	0.2182	0.6125	0.2810	0.4757	0.3785
2	2003	0.5033	24	0.3126	0.8105	0.3947	0.6418	0.5184
3	2004	0.4568	24	0.2812	0.7419	0.3566	0.5850	0.4710
4	2005	0.6297	23	0.3970	0.9988	0.4977	0.7968	0.6474
5	2006	0.4395	25	0.2685	0.7194	0.3418	0.5651	0.4536
6	2007	0.3466	25	0.2085	0.5762	0.2674	0.4492	0.3585
7	2008	0.4006	25	0.2408	0.6664	0.3090	0.5194	0.4143
8	2009	0.9492	34	0.4870	1.8501	0.6753	1.3342	1.0058

```
 Separable Model: Selection (S) by age
    9      0     0.0329  29    0.0183    0.0591    0.0244    0.0444    0.0344
   10      1     0.4922  22    0.3183    0.7609    0.3940    0.6147    0.5045
           2     1.0000     Fixed : Reference Age
   11      3     1.6252  18    1.1326    2.3321    1.3517    1.9540    1.6530
           4     1.0000     Fixed : Last true age

 Separable model: Populations in year 2009
   12      0   68480224  76   15185560 308815803  31755808 147675068  92002669
   13      1   28184154  29   15800985  50271963  20978774  37864299  29439751
   14      2   23008268  24   14148570  37415824  17953265  29486582  23727291
   15      3    4711726  25    2885291   7694321   3668694   6051298   4861558
   16      4     736662  26     436330   1243718    563924    962313    763437

Separable model: Populations at age
   17   2002     819346  40     372920   1800192    548345   1224282    888158
   18   2003    2045613  30    1123059   3726015   1506453   2777739   2143622
   19   2004    1276923  29     720901   2261799    953864   1709397   1332416
   20   2005     984183  27     578141   1675397    750235   1291084   1021112
   21   2006     478896  28     275381    832814    361107    635107    498365
   22   2007     488055  27     283106    841374    369654    644380    507264
   23   2008     613881  26     365733   1030395    471334    799538    635690
```

```
 Age-structured index catchabilities
                                       Bul

 Linear model fitted. Slopes at age :
   24   1  Q  .2281E-02  23 .1829E-02 .4509E-02 .2281E-02 .3615E-02 .2949E-02
   25   2  Q  .7438E-02  23 .5957E-02 .1474E-01 .7438E-02 .1181E-01 .9626E-02
   26   3  Q  .9632E-02  23 .7678E-02 .1938E-01 .9632E-02 .1545E-01 .1254E-01
   27   4  Q  .5416E-02  24 .4277E-02 .1122E-01 .5416E-02 .8861E-02 .7141E-02

                                       Ukr

 Linear model fitted. Slopes at age :
   28   1  Q  .5006E-02  23 .4014E-02 .9893E-02 .5006E-02 .7932E-02 .6471E-02
   29   2  Q  .1174E-01  23 .9404E-02 .2327E-01 .1174E-01 .1864E-01 .1519E-01
   30   3  Q  .2298E-01  23 .1832E-01 .4624E-01 .2298E-01 .3686E-01 .2993E-01
   31   4  Q  .7920E-02  24 .6254E-02 .1641E-01 .7920E-02 .1296E-01 .1044E-01

                                       RI

 Linear model fitted. Slopes at age :
   32   0  Q  .1864E-04  16 .1599E-04 .2995E-04 .1864E-04 .2568E-04 .2216E-04
```

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	2002	2003	2004	2005	2006	2007	2008	2009
0	-0.644	0.237	-0.633	-0.868	0.016	1.004	0.907	0.000
1	-0.111	-0.174	0.250	-0.143	0.088	-0.067	-0.089	0.555
2	0.300	-0.107	0.037	0.161	0.018	-0.324	-0.207	-0.222
3	0.063	0.052	0.332	0.041	-0.133	-0.010	0.113	0.203
4	0.090	0.216	-0.117	0.177	-0.217	0.177	0.222	0.165

AGE-STRUCTURED INDEX RESIDUALS

Bul

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	-1.131	-0.644	-0.270	0.073	0.042	0.516	-0.320	-0.254	-0.283	0.236	0.452	0.205	0.292	-0.106	-0.184
2	1.356	0.698	0.118	-0.655	0.197	-0.458	0.170	-0.809	-0.486	-0.238	0.054	-0.085	-0.064	-0.323	0.020
3	2.303	1.172	0.589	-0.316	-0.963	-1.034	-0.691	-1.625	-0.687	-0.467	-0.117	0.056	-0.354	-0.083	1.166
4	1.159	0.843	1.095	0.012	-0.611	-1.589	-0.910	-1.978	-0.682	-0.473	0.348	-0.612	0.596	0.357	1.091

Bul

Age	2009
1	1.376
2	0.506
3	1.051
4	1.355

Ukr

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.626	-0.011	-0.060	-0.628	-0.613	-0.306	-0.271	-0.249	-0.241	-0.520	0.107	0.077	0.409	-0.226	0.332
2	1.164	0.996	0.793	-0.537	-0.107	0.112	0.466	-0.595	0.056	-0.535	-0.566	0.279	0.053	-1.221	-0.672
3	0.729	0.550	-0.283	-0.659	0.344	0.207	0.798	-0.612	-0.284	-0.402	0.038	0.015	-0.044	-0.576	-0.005
4	1.508	-0.072	0.835	-0.194	0.481	-1.342	1.020	0.014	0.324	0.327	0.011	0.823	0.284	-3.006	0.215

Ukr

Age	2009
1	1.574
2	0.316
3	0.185
4	-1.228

RI

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	1.363	-1.096	0.141	*******	-0.346	1.239	0.597	*******	*******	0.282	*******	-0.433	-1.747

PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)

Separable model fitted from 2002 to 2009	
Variance	0.1737
Skewness test stat.	1.3970
Kurtosis test statistic	0.8540
Partial chi-square	0.2104
Significance in fit	0.0000
Degrees of freedom	17

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR Bul

Linear catchability relationship assumed

Age	1	2	3	4
Variance	0.0769	0.0728	0.2590	0.2597
Skewness test stat.	0.7057	1.3652	1.0291	-0.6188
Kurtosis test statisti	0.9544	0.5726	-0.1404	-0.7497
Partial chi-square	0.1096	0.1052	0.4541	0.5919
Significance in fit	0.0000	0.0000	0.0000	0.0000
Number of observations	16	16	16	16
Degrees of freedom	15	15	15	15
Weight in the analysis	0.2500	0.2500	0.2500	0.2500

DISTRIBUTION STATISTICS FOR Ukr

Linear catchability relationship assumed

Age	1	2	3	4
Variance	0.0758	0.1099	0.0522	0.2942
Skewness test stat.	2.3888	0.1524	0.3534	-2.2547
Kurtosis test statisti	1.8032	-0.6160	-0.7534	1.5123
Partial chi-square	0.1000	0.1503	0.0804	0.6301
Significance in fit	0.0000	0.0000	0.0000	0.0000
Number of observations	16	16	16	16
Degrees of freedom	15	15	15	15
Weight in the analysis	0.2500	0.2500	0.2500	0.2500

DISTRIBUTION STATISTICS FOR RI

Linear catchability relationship assumed

Age	0
Variance	1.0508
Skewness test stat.	-0.3160
Kurtosis test statisti	-0.5318
Partial chi-square	1.2177
Significance in fit	0.0035
Number of observations	9
Degrees of freedom	8
Weight in the analysis	1.0000

ANALYSIS OF VARIANCE

Unweighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	85.1191	177	32	145	0.5870
Catches at age	4.6821	40	23	17	0.2754
Aged Indices					
Bul	40.1067	64	4	60	0.6684
Ukr	31.9235	64	4	60	0.5321
RI	8.4067	9	1	8	1.0508

Weighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	15.8623	177	32	145	0.1094
Catches at age	2.9537	40	23	17	0.1737

Aged Indices					
Bul	2.5067	64	4	60	0.0418
Ukr	1.9952	64	4	60	0.0333
RI	8.4067	9	1	8	1.0508

4.1.6.4 Differences with the assessement in 2008

In the previous assessments (Pilling et al. 2008, Daskalov et al. 2009) the input data matrix was characterized by relatively low selection of older fish (age 3 and 4). In the previous assessments we used age composition (and age-length keys) from Bulgarian sprat catches (in combination some length composition data from Turkey and Ukraine) to derive total catch-at-age matrix. As a result the total catch age structure was driven mainly by age composition of Bulgarian catch.The low selection of older (and larger) fish has been due to the economic constraints of small vessels, used in the Bulgarian fishery operating in shallower waters. During the 1980 when the highest catches were realised, the former Soviet fleet was deploying larger vessels fishing in in deeper water where larger fish is preferably distributed (Prodanov et al. 1997, Daskalov 1998, , Daskalov et al. 2008) and age composition of the landings was more representative for the stock age composition (unselective fishing of larger/older fish).

In the previous assessment a low selectivity at the last age was applied (S at age 4 as a ratio of F at age 4 to reference F -in this case F at age 2). A problem has arisen how to establish the selectivity in a objective way and this was done by running ICA with several values of S4 and selecting the run with the lowest SSR (Daskalov et al. unpublished).

In this assessment complete (true) age composition of Ukrainian catches (which dominate the total catch) was used that drove the total catch-at-age matrix in the direction of having higher proportions of larger and older (age 3 and 4) fish. It was then acceptable to run the ICA using a constant selection pattern in 2002-2009 (Fig. 1.8.3.3, Table 1.8.2.1.) with reference F at age 2 and selection at the last age S4 = 1. Therefore, in this assessment we did not have a problem of which exactly value of selectivity less than 1 to set, that we had in the previous assessment.

4.1.7 Short term prediction of stock biomass and catch

4.1.7.1 Justfication

A deterministic short term prediction of stock size and catch was conducted based on ICA results.

4.1.7.2 Input parameters

The input parameters are listed in the Table 4.1.7.2.1 below. They do represent short term averages of the ICA inputs. The exploitation pattern used is the 2008 estimated vector rescaled to the average exploitation patterns estimated for the years 2007-2009. Due to the poor fit between the recruitment and survey index age 0 was set at the average level from 2005-2007.

As the fishery for sprat in the Black Sea is not constrained by an international TAC, the intermediate year 2010 was defined as a status quo effort year with unchanged fishing mortality.

Table 4.1.7.2.1. Sprat in the Black Sea. Input to short term prediction.

2010

age	stock size (000)	M	maturity	weight in stock (kg)	exploitation pattern	weight in catch (kg)
0	98570000	0.6400	0.0000	0.001	0.0406	0.0024
1	35430000	0.9500	1.0000	0.0031	0.3169	0.0031
2	8140000	0.9500	1.0000	0.0041	0.5589	0.004
3	4870000	0.9500	1.0000	0.0047	0.9928	0.0049
4	690000	0.9500	1.0000	0.0054	0.7614	0.006
5	260000	0.9500	1.0000	0.01	0.7614	0.01

2011

age	stock size (000)	M	maturity	weight in stock (kg)	exploitation pattern	weight in catch (kg)
0	98570000	0.6400	0.0000	0.001	0.0406	0.0024
1		0.9500	1.0000	0.0031	0.3169	0.0031
2		0.9500	1.0000	0.0041	0.5589	0.004
3		0.9500	1.0000	0.0047	0.9928	0.0049
4		0.9500	1.0000	0.0054	0.7614	0.006
5		0.9500	1.0000	0.01	0.7614	0.01

2012

age	stock size (000)	M	maturity	weight in stock (kg)	exploitation pattern	weight in catch (kg)
0	98570000	0.6400	0.0000	0.001	0.0406	0.0024
1		0.9500	1.0000	0.0031	0.3169	0.0031
2		0.9500	1.0000	0.0041	0.5589	0.004
3		0.9500	1.0000	0.0047	0.9928	0.0049
4		0.9500	1.0000	0.0054	0.7614	0.006
5		0.9500	1.0000	0.01	0.7614	0.01

4.1.7.3 Results

The following table Tabl. 4.1.7.3.1 lists the single option status quo results of the prediction with stock parameters at age for 2010 to 2012.

Table 4.1.7.3.1. Sprat in the Black Sea. Single option (status quo) short term prediction.

2010	F-factor:	1	reference F1-3	0.6229		1 January	
age	absolute F	catch in numbers (000)	catch in weight (t)	stock size (000)	stock biomass (t)	sp. stock size (000)	sp. stock biomass (t)
0	0.0406	2901187	6963	98570000	98570	0	0
1	0.3169	6366416	19736	35430000	109833	35430000	109833
2	0.5589	2348161	9393	8140000	33374	8140000	33374
3	0.9928	2132019	10447	4870000	22889	4870000	22889
4	0.7614	251547	1509	690000	3726	690000	3726
5	0.7614	94786	948	260000	2600	260000	2600
		14094116	48996	147960000	270992	49390000	172422
2011	F-factor:	1	reference F1-3	0.6229		1 January	
age	absolute F	catch in numbers (000)	catch in weight (t)	stock size (000)	stock biomass (t)	sp. stock size (000)	sp. stock biomass (t)
0	0.0406	2901187	6963	98570000	98570	0	0
1	0.3169	8968056	27801	49908493	154716	49908493	154716
2	0.5589	2879070	11516	9980421	40920	9980421	40920
3	0.9928	788126	3862	1800252	8461	1800252	8461
4	0.7614	254419	1527	697879	3769	697879	3769
5	0.7614	45430	454	124617	1246	124617	1246
		15836288	52123	161081662	307682	62511662	209112
2012	F-factor:	1	reference F1-3	0.6229		1 January	
age	absolute F	catch in numbers (000)	catch in weight (t)	stock size (000)	stock biomass (t)	sp. stock size (000)	sp. stock biomass (t)
0	0.0406	2901187	6963	98570000	98570	0	0
1	0.3169	8968056	27801	49908493	154716	49908493	154716
2	0.5589	4055604	16222	14058927	57642	14058927	57642
3	0.9928	966318	4735	2207282	10374	2207282	10374
4	0.7614	94049	564	257979	1393	257979	1393
5	0.7614	45949	459	126040	1260	126040	1260
		17031163	56744	165128721	323955	66558721	225385

The *status quo* fishing in 2010 would result in decreased landings around 49 000t, and SSB around 172 000 t, compared to the 91 000 t landed in 2009 and 276 308 t SSB respectively. This decrease can be interpreted as a result of the rise in fishing mortality due to the expenditure of Turkish sprat catches which in 2008 and 2009 increased more than 4 times compared to 2007. A relative increase in sprat biomass and catches in 2009 was predicted by the last year Black Sea WG (Daskalov et al. 2009) but actually happened at a higher degree. The status quo prediction results in a catch of 52 100 t in 2011, implying an increase in SSB to 225 000 t at the beginning of 2012.

SSB and catches are expected to gradually increase in 2011 and 2012 under the status quo F assumption. Thus, status quo fishing would halt the decreasing trend in SSB and stabilise the landings even under the assumed medium level of recruitment.

Given that the state of the stock depends greatly on a variable recruitment, the dynamic nature of developing Turkish sprat fishery and the lack of quota constraints on the sprat fisheries, the status quo assumption must be taken with a caution when considered in management advice.

Table 4.1.7.3.2. Sprat in the Black Sea. Management option table for the term prediction based on ICA output.

2010					2011					2012	
F-factor	reference F	stock biomass	sp. stock biomass	catch in weight	F-factor	reference F	stock biomass	sp. stock biomass	catch in weight	stock biomass	sp. stock biomass
1.0000	0.6229	270992	172422	48996	0.0000	0.0000	308152	209582	0	364094	265524
					0.1000	0.0658	308152	209582	6038	359398	260828
					0.2000	0.1315	308152	209582	11869	354887	256317
					0.3000	0.1973	308152	209582	17501	350549	251979
					0.4000	0.2630	308152	209582	22945	346374	247804
					0.5500	0.3616	308152	209582	30776	340409	241839
					0.6000	0.3945	308152	209582	33304	338491	239921
					0.7000	0.4603	308152	209582	38232	334765	236195
					0.8000	0.5260	308152	209582	43008	331173	232603
					0.9000	0.5918	308152	209582	47637	327707	229137
					1.0000	0.6575	308152	209582	52123	324362	225792
					1.1000	0.7233	308152	209582	56474	321133	222563
					1.2000	0.7890	308152	209582	60697	318013	219443
					1.3000	0.8548	308152	209582	64798	314999	216429
					1.4000	0.9205	308152	209582	68777	312084	213514
					1.5000	0.9863	308152	209582	72647	309263	210693

4.1.8 Medium term prediction of stock biomass and catch

The WG did not undertake medium term projections.

4.1.9 Long term prediction method 1: Yield per Recruit

4.1.9.1 Input parameters

Table 4.1.9.1.1 represents the input parameters to the YPR analysis. They are derived from long term means of the ICA input data (2000-2009) except the exploitation pattern, which was estimated as the 2009 exploitation pattern rescaled to the average of the years 2007-2009.

Table 4.1.9.1.1. Sprat in the Black Sea. Input parameters to YPR analysis.

age min	age group	stock weight	catch weight	maturity	F	M
0	0	0.001	0.0024	0	0.0406	0.64
age max	1	0.0031	0.0031	1	0.3169	0.95
5	2	0.0041	0.004	1	0.5589	0.95
Fref	3	0.0047	0.0049	1	0.9928	0.95
0.6229	4	0.0054	0.006	1	0.7614	0.95
	5	0.01	0.01	1	0.7614	0.95

4.1.9.2 Results

Fmax could not be estimated due to shape to the YpR curve, which has a maximum well outside of the reasonable range. The skewed shape of the YpR curve results from the high natural mortality and the short life span of sprat in the Black Sea (Fig. 4.1.9.2.1.). Due to such effects, STECF SG Black Sea refused to propose the estimated $F_{0.1}$= 2.17 as an appropriate management reference point.

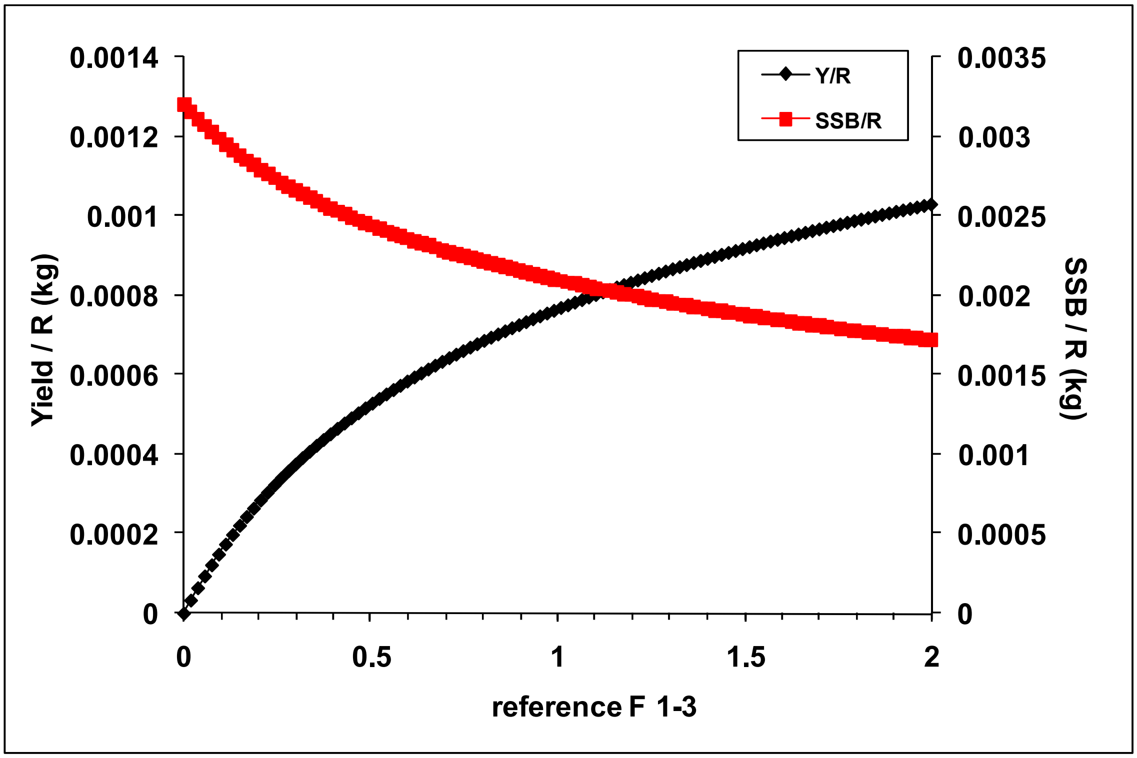


Fig. 4.1.9.2.1 Sprat in the Black Sea. YpR and SSBpR with increasing fishing mortality (average of ages 1-3).

4.1.10 Long term prediction method 2: Age structured production model

4.1.10.1 Input parameters

Table 4.1.10.1.1 lists all input parameters used to estimate MSY, Fmsy and Bmsy. Such parameters were derived from the ICA assessment described in the previous sections and present long term means with the exception of the exploitation pattern, which was estimated as the 2009 exploitation pattern rescaled to the average of the years 2007-2009. The recruitment was estimated applying the Ricker function shown in Fig. 4.1.10.1.1. A reasonably close relationship between the SSB and recruitment appears.

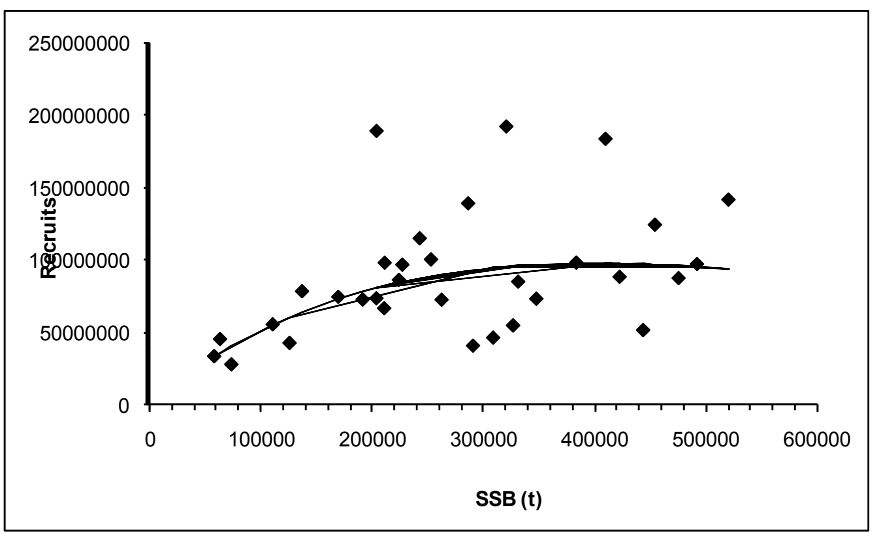


Fig. 4.1.10.1.1 Sprat in the Black Sea. Spawning stock recruitment relationship expressed as the Ricker function. Parameters are given in Tab. 4.1.10.1.1

Table 4.1.10.1.1 Sprat in the Black Sea. Input parameters to the production model.

age min	age group	stock weight	catch weight	maturity	F	M	R=a*SSB*exp(-SSB/k)	
0	0	0.001	0.0024	0	0.0406	0.64	a=	660.03
age max	1	0.0031	0.0031	1	0.3169	0.95	k=	403589.76
5	2	0.0041	0.004	1	0.5589	0.95	sterror=	39970937.5
F 1-3	3	0.0047	0.0049	1	0.9928	0.95		
0.6229	4	0.0054	0.006	1	0.7614	0.95		
	5	0.01	0.01	1	0.7614	0.95		

4.1.10.2 Results

According to the results of the production model the MSY is estimated to be in the range of 47 997 t.
Fmsy (ages 1-3) amounts to 0.953. Bmsy appears to be in the range of 136 000 t. Thus, the present level of fishing mortality is below the equilibrium Fmsy, but catches exceed the equilibrium level almost twice.

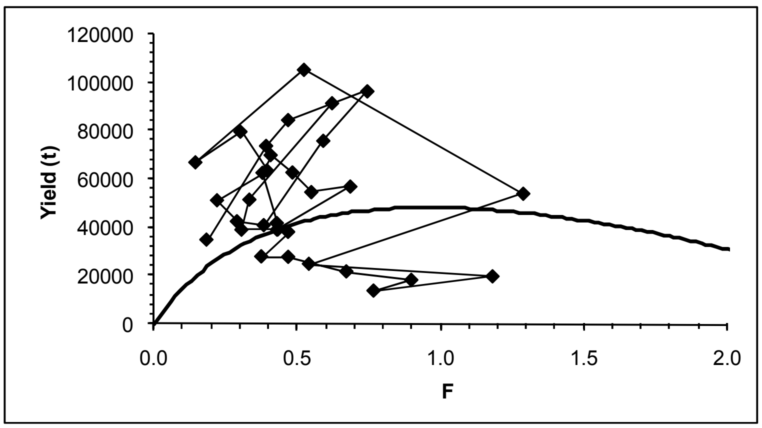


Fig. 4.1.10.2.1 Sprat in the Black Sea. Relation between yield and fishing mortality (F1-3) observed (linked dots) and its estimated sustainable levels.

4.1.11 Scientific advice

4.1.11.1 Short term considerations

The WG accepted the current ICA assessment as adequately presenting the state and dynamics of the stock and the development of the fisheries.

State of the spawning stock size: According to the present assessment in recent years the SSB in an average level in the range of 200 -300 000 t. Under constant recruitment scenario and status quo F, SSB is expected to stay at the level of 225 000 t by 2012.

State of recruitment: After a positive trend in 1999-2001 the recruitment has decreased in 2002-2004 and slightly increased in 2005-2007 and again decreased in 2008. Recruitment estimates in 2008 and 2009 are rather imprecise due to the lack of good survey data. In short-term forecast we used a 2006-2008 average value of 98 570 000.

State of exploitation: Over the last few years the fishing mortality has piqued in 2005 and 2009 at a level of about F=0.6. This equals an exploitation rate of about E=0.39 (natural mortality M=0.95). Proposing a limit reference point of exploitation rate E≤0.4, the WG considers the stock of sprat in the Black Sea as sustainably exploited. Status quo fishing implies a catch of 52 100 t in 2011.

4.1.11.2 Medium term considerations

Due to the cyclic nature of recruitment and unknown dependence on environmental conditions the WG is not able to provide medium term forecast. After low-to-medium recruitment and relatively strong exploitation the stock is now at an average level but if a higher recruitment appears it could possibly recover to a higher level, given that exploitation is kept no higher than the present level.

4.2 Turbot in the Black Sea

4.2.1 Stock Identification

Turbot (*Psetta maxima*) occurs all over the shelf area of all Black Sea coastal states at depths up to 100 m - 140 m, grouped in local shoals. Species habitats are sandy and mixed bottoms or mussel beds. Turbot in the Black Sea is represented by several local populations mixing in the adjacent zones. Local populations are independent units of the stock, and it is specially important to cover them all in order to provide an accuarate assessessment of the stock. This is very difficult in practice, due to numerous gaps of information, therefore the present assessment is based on the analysis of combined fisheries data of all Black Sea countries.

4.2.2 Growth

Turbot is a long living species with a slow growth rate. The parameters reported here by countries are considered appropriate for the description of an average growth performance of the species in GSA 29 – Tab. 4.2.2.1.

Table 4.2.2.1 Growth parameters of turbot by countries.

COUNTRY	AREA	YEAR_PERIOD	SPECIES	SEX	L_INF	K	t_0	A	B
ROM	29	2003-2005	TUR	C	80.98	0.15	-1.37	0.000018	3.01
ROM	29	2006-2008	TUR	C	72.5	0.212	-1.15	0.00806	3.22
ROM	29	2009-2011	TUR	C	86.3	0.19	-2.1	0.030088	2.87
BGR	29	2007-2008	TUR	C	77.81	0.242	0.152	0.000431	2.21
BGR	29	2008-2009	TUR	C	120.40	0.076	-2.811	0.000011	3.13
BGR	29	2008-2009	TUR	F	129.81	0.065	-3.351	0.000013	3.11
BGR	29	2008-2009	TUR	M	67.38	0.246	-1.217	0.000041	2.78
BGR	29	2007-2008	TUR	M	57.60	0.507	0.458	0.000918	1.96
BGR	29	2007-2008	TUR	F	80.31	0.213	-0.136	0.000424	2.22
BGR	29	2006-2007	TUR	M	77.49	0.158	-1.975	0.000022	2.92
BGR	29	2006-2007	TUR	F	124.27	0.080	-2.136	0.000021	2.94
BGR	29	2006-2007	TUR	C	79.26	0.173	-1.561	0.000008	3.17
UKR (NE)	29	2000 - 2006	TUR	C				0.000216	2.48
UKR (NW)	29	2008 - 2009	TUR	C	74	0.106	-1.73	0.001437	1.94
TR	29	1990 - 1991	TUR	C	82.57	0.17	-0.93	0.0085	3.18
TR	29	1990 - 1996	TUR	C	96.24	0.119	-0.01		
TR	29	1998 - 2000	TUR	C	95.9	0.104	-1.55	0.0106	3.14

4.2.3 Maturity

The species reaches sexual maturity at ages between 3 and 5. The accepted proportions of mature individuals by age according to recent data by countries in GSA 29 are given in Table 4.2.3.1.

Table 4.2.3.1. Common maturity ogive of turbot by ages.

Age	1	2	3	4	5	6	7	8	9	10
MO	0	0	0.45	0.7	0.95	1	1	1	1	1

4.2.4 Fisheries

4.2.4.1 General description of fisheries

The STECF SG-RST 10-03 noted that the Turbot (Psetta maxima) is the one of the most important demersal fish species in the Black Sea with high market demand and prices. Main fishing gear for all coastal states are gillnets, but in Turkey, the bottom trawling is also permitted. The turbot is often caught as a by-catch of sprat fishery, long lines and purse seiners fishery. Turbot catches are higher in spring and autumn periods: March – April and October – November for Bulgaria and Romania; May – June for Ukraine, March - April and September – October for Turkey. Annual landings during last 5 years range between 730 and 1035 t . Misreporting and illegal catches also occur.

4.2.4.2 Management regulations applicable in 2009 and 2010

The TAC's and quotas for turbot in 2009 and 2010 and quotas allocation to the Member States was introduced regarding to Council Regulations (EC) No 1137/2008 and No 1287/2009. Both for Bulgaria and Romania quotas of 50 t in 2009 and 48 t in 2010 for each country were permitted.

Prohibition of fishing activity for turbot was in force from 15 April to 15 June in European Community waters of the Black Sea in relation to pick reproduction period of tiurbot.

The minimum legal mesh size for bottom-set nets used to catch turbot should be 400 mm. In cases when in the Member States legislation the minimum legal mesh size for bottom-set nets used to catch turbot was less than 400 mm before the entry into force of this Regulation, nets with a minimum mesh size of no less than 360 mm may be used to catch turbot. However, the Member State concerned have to ensure that by the end of 2009 no more than 40 % by number of the whole fishing vessels authorised to fish turbot with bottom-set nets still use a mesh size smaller than 400 mm.

In Ukraine Turbot fisheries is conducted with bottom (turbot) gill nets with minimum mesh size 180 - 200 mm. The use of bottom trawls has been prohibited. Turbot exploitation in Ukraine has been regulated by TACs since 1996.

The Regulations of Fisheries determine the following standards regulating the fisheries of the Black Sea turbot:
- minimum commercial fishing size – 35 cm (SL);
- allowable by-catch of its juveniles – during the non-target fisheries not more than 2% of total catch weight, during the target fisheries with nets (with mesh size 180 mm) not more 5% by counting;
- during target long-lining of picked dogfish and Rajiformes by-catch of turbots is allowed, at the amount of not more than 20% of its juveniles by counting;
- turbot by-catch is allowed in trawl catches of sprat not more than 4 individuals a commercial fishing length per one ton of catch;
- in the period of abundant spawning of turbot in the coastal 12-mile zone a temporal prohibition for 15 – 30 days is implemented for harvesting of fish with trawls, net and long-lines (such prohibition may be imposed gradually).

In Turkey turbot target fisheries is conducted with bottom (turbot) gill nets with minimum mesh size 160 – 200 mm (Tonay, Öztürk, 2003) and with bottom trawls with minimum mesh size 40 mm. The minimum admissible landing size in Turkey is 40 cm total length. In Turkey – no TAC regulation of turbot catches. Seasonal fishing closures in Turkey are: for bottom trawls from 1st September – 15th April and for gillnets – from 1th May up to 30th June.

4.2.4.3 Landings

Landings data for Bulgaria and Romania were reported to STECF SG-RST 10-03 through the EU Data collection program and for the Turkey and Ukraine – according to the official statistics of each country. Since 2002 total annual landings varied between 618 and 1035 tons (Tab. 4.2.4.3.1). The data set of landings by countries was compiled for the period 1989 – 2009.

Table 4.2.4.3.1. Landings of turbot in the Black Sea during the period 1989 – 2009.

Year	Bulgaria	Romania	Ukraine west	Ukraine east	Turkey west	Turkey east	Russian Federation	Georgia	Black Sea total	Black Sea west
1989	0.9	0	2	0	448	1001	0	8	1459.9	450.9
1990	0	0	9	0	908	475	0	1	1393	917
1991	0	2	17.1	0.9	600	315	0	0	935	619
1992	0	1	18	1	308	110	1	0	439	327
1993	0	6	10	0	400	1185	2	0	1603	416
1994	0	6	18	1	1293	821	5	0	2144	1317
1995	60	4	10	0	2006	844	19	0	2943	2080
1996	62	6	37	2	1414	510	17	0	2048	1519
1997	60	1	40	2	777	134	11	0	1025	878
1998	64	0	40	2	1056	412	14	0	1588	1160
1999	54	2	69	4	1579	225	15	5	1953	1704
2000	55.1	2	76	4	2321	318	4	9	2789.1	2454.1
2001	56.5	13	123	6	2169	154	24	11	2556.5	2361.5
2002	135.5	16.681	99	5.47	193	142	15	11	617.97	444.5
2003	40.8	23.978	118	5.876	126	93	15	1	423.676	308.8
2004	16.2	42.031	126	7.157	118	116	1.7	7	434.357	302.2
2005	12.69	36.53	123	6	273	275	7.5	7	747.69	445.69
2006	14.81	35.108	154	8	266	481	7.6		962.81	466.81
2007	66.852	48.064	205	10.58	346	353	5.7		1035.396	666
2008	54.621	47.112	239	12.35	224	234	4.7		815.786	565
2009	52.47	48.767	247	16	223	119	24.3		730.537	571

4.2.4.4 Discards

No data from discards surveys have been reported to STECF SG Black Sea-10-01.

4.2.4.5 Fishing effort

Fishing effort data for Bulgaria and Romania were reported to STECF SG Black Sea-10-01 through the Data collection program (Tab. 4.2.4.5.1.)

Tab. 4.2.4.5.1. Fishing effort data in EC area during the period 2007 – 2009.

COUNTRY	AREA	YEAR	FT_LVL3	FT_LVL4	FT_LVL5	FT_LVL6	DAYS	GTDAYS	KWDAYS	FT_LVL	VESSEL_LENGTH
BGR	29	2009	LL	LLS	MDPSP	NA	17	9.74	157.69	5	VL0006
BGR	29	2008	NE	GNS	DEMSP	380SXX	1646	1239	10339	5	VL0006
BGR	29	2007	NE	GNS	DEMSP	380SXX	230	5429	28954	5	VL1824
BGR	29	2007	NE	GNS	DEMSP	380SXX	229	5408.83	28858.11	5	VL1218
BGR	29	2007	NE	GNS	DEMSP	380SXX	735	1651.27	16683.79	5	VL0612
BGR	29	2007	NE	GNS	DEMSP	380SXX	468	314.31	2280.62	5	VL0006
BGR	29	2009	PT	OTM	MDPSP	12SXX	1671	207590.4	409072.4	5	VL2440
BGR	29	2009	PT	OTM	MDPSP	12SXX	573	36160.33	118870.3	5	VL1824
BGR	29	2009	PT	OTM	MDPSP	12SXX	652	15272.3	121863.9	5	VL1218
BGR	29	2009	LL	LLS	MDPSP	NA	3	103.8	477.43	5	VL1824
BGR	29	2009	LL	LLS	MDPSP	NA	12	246.59	1375.32	5	VL1218
BGR	29	2009	LL	LLS	MDPSP	NA	24	130.39	1144.36	5	VL0612
BGR	29	2008	NE	GNS	DEMSP	380SXX	3069	5998	71296	5	VL0612
BGR	29	2008	NE	GNS	DEMSP	380SXX	97	455	18370	5	VL1824
BGR	29	2008	NE	GNS	DEMSP	380SXX	180	3681	23831	5	VL1218
BGR	29	2008	LL	LLS	MDPSP	NA	5	187	992	5	VL1824
BGR	29	2008	LL	LLS	MDPSP	NA	33	688	3194	5	VL1218
BGR	29	2008	LL	LLS	MDPSP	NA	24	130	1144	5	VL0612
BGR	29	2008	LL	LLS	MDPSP	NA	59	34	155	5	VL0006
BGR	29	2007	LL	LLS	MDPSP	NA	56	1327	7511	5	VL1824
BGR	29	2007	LL	LLS	MDPSP	NA	55	1294.54	7251.33	5	VL1218
BGR	29	2007	LL	LLS	MDPSP	NA	15	104.22	1403.04	5	VL0612
BGR	29	2007	LL	LLS	MDPSP	NA	3	1.78	5.88	5	VL0006
BGR	29	2008	PT	OTM	MDPSP	12SXX	1379	171135	335647	5	VL2440
BGR	29	2008	PT	OTM	MDPSP	12SXX	430	28081	83527	5	VL1824
BGR	29	2008	PT	OTM	MDPSP	12SXX	323	8254	66989	5	VL1218
BGR	29	2007	PT	OTM	MDPSP	12SXX	1436	169246.3	322022.4	5	VL2440
BGR	29	2007	PT	OTM	MDPSP	12SXX	278	6787	65598	5	VL1824
BGR	29	2007	PT	OTM	MDPSP	12SXX	275	6689.52	65200.74	5	VL1218
BGR	29	2009	NE	GNS	DEMSP	400SXX	88	3884.84	16273.33	5	VL1824
BGR	29	2009	NE	GNS	DEMSP	400SXX	191	3851.03	26409.64	5	VL1218
BGR	29	2009	NE	GNS	DEMSP	400SXX	3069	5998.08	71296.42	5	VL0612
BGR	29	2009	NE	GNS	DEMSP	400SXX	2502	1665.23	20114.36	5	VL0006
ROM	29	2002	PT	OTM	MDPSP	00D14	878	706790	1862238	4	VL2440
ROM	29	2003	PT	OTM	MDPSP	00D14	743	769005	2026161	4	VL2440
ROM	29	2004	PT	OTM	MDPSP	00D14	762	701040	1847088	4	VL2440
ROM	29	2005	PT	OTM	MDPSP	00D14	788	815580	2148876	4	VL2440
ROM	29	2006	PT	OTM	MDPSP	00D14	760	699200	1842240	4	VL2440
ROM	29	2007	PT	OTM	MDPSP	00D14	290	100050	263610	4	VL2440
ROM	29	2008	PT	OTM	MDPSP	00D14	99	22770	59994	4	VL2440
ROM	29	2009	PT	OTM	MDPSP	00D14	56	19320	50904	4	VL2440
ROM	29	2002	TR	FPN	MDPSP	00D14	3341	79182	531219	4	VL0012
ROM	29	2003	TR	FPN	MDPSP	00D14	3573	84680	568107	4	VL0012
ROM	29	2004	TR	FPN	MDPSP	00D14	3125	74063	496875	4	VL0012
ROM	29	2005	TR	FPN	MDPSP	00D14	2750	65175	437250	4	VL0012
ROM	29	2006	TR	FPN	MDPSP	00D14	2510	59487	399090	4	VL0012
ROM	29	2007	TR	FPN	MDPSP	00D14	1560	36972	248040	4	VL0012
ROM	29	2008	TR	FPN	MDPSP	00D14	1360	32232	216240	4	VL0012
ROM	29	2009	TR	FPN	MDPSP	00D14	1170	27729	186030	4	VL0012
ROM	29	2002	NE	GNS	DEMF	100D400	125	7725	35700	4	VL2440
ROM	29	2003	NE	GNS	DEMF	100D400	150	9270	42840	4	VL2440
ROM	29	2004	NE	GNS	DEMF	100D400	225	13905	64260	4	VL2440
ROM	29	2005	NE	GNS	DEMF	100D400	205	12669	58548	4	VL2440
ROM	29	2006	NE	GNS	DEMF	100D400	192	11866	54835	4	VL2440
ROM	29	2007	NE	GNS	DEMF	100D400	250	15450	71400	4	VL2440
ROM	29	2008	NE	GNS	DEMF	100D400	210	12978	59976	4	VL0012
ROM	29	2009	NE	GNS	DEMF	100D400	205	12669	58548	4	VL0012

No data were available for fishing effort and CPUE from Ukraine.

The number of fishing vessels, operating in Turkish Black Sea area on turbot are given on Tabl. 4.2.4.5.2.

Table 4.2.4.5.2. Number of Turkish fishing vessels, working on turbot in the Black Sea area.

Year	Vessels (in Nbs)
1987	102
1988	89
1989	96
1990	223
1991	94
1992	273
1993	286
1994	204
1995	166
1996	298
1997	266
1998	264
1999	338
2000	340
2001	286
2002	300
2003	133
2004	141
2005	212
2006	231
2007	206
2008	263
2009	237

4.2.5 Scientific surveys

4.2.5.1 List of demersal surveys

Based on the DCF data call, abundance and biomass indices were calculated for the Bulgarian (Panayotova et.al., 2008b, 2009, 2010) and Romanian waters (Maximov et al, 2009; Maximov et al, 2010a, Maximov et al, 2010b; Radu et al, 2009a; Radu et al, 2009b, Radu et al, 2010a; Radu et al, 2010b) in spring and autumn seasons by swept area method. In the Black Sea the following number of hauls was reported per depth stratum (Tab. 4.2.5.1.1).

Table 4.2.5.1.1. Number of hauls per depth stratum by seasons in 2009.

Country	Period	Stratum	Number of hauls
BG	April - May	15 - 35 m	4
		35 - 50 m	12
		50 - 75 m	17
		75 - 100 m	14
	November - December	15 - 35 m	3
		35 - 50 m	9
		50 - 75 m	14
		75 - 100 m	9
ROU	May	15 - 35 m	7
		35 - 50 m	14
		50 - 75 m	11
	October - November	15 - 35 m	8
		35 - 50 m	13
		50 - 75 m	13

For estimation of abundance and biomass of turbot stocks in Bulgarian and Romanian waters swept area method and standard methodology for stratified sampling were used (Sparre, Venema, 1998; Sabatella,Franquesa, 2004). The region was divided in four strata according to depth – 15 – 35 m, 35 – 50 m, 50 – 75 m and 75 – 100 m and sampling by means of bottom trawling was carried out in a selected number of the fields chosen at random into each stratum. The data obtained in the sampling fields were extrapolated over the whole stratum.

For the estimation of turbot biomass, the catch per unit of area (CPUA) is used:

$$\frac{C_{w/t}}{a/t} = \frac{Cw}{a} kg/km^2$$

where: $C_{w/t}$ – catch in weight per unit of area, a/t – the area swept per hour.

The biomass of turbot for each stratum is obtained from:

$$B = \left(\overline{C_{w/a}}\right) * A$$

where: $\overline{C_{w/a}}$ - the mean catch per unit area of all hauls, A – the total size of the area under investigation in stratum.

The variance of biomass estimate for each stratum is:

$$VAR(B) = A^2 * \frac{1}{n} * \frac{1}{n-1} * \sum_{i=1}^{n} \left[Ca(i) - \overline{Ca}\right]^2$$

The mean catch for the entire survey area is obtained from:

$$\overline{Ca}(A) = \frac{Ca1 * A1 + Ca2 * A2 + Ca3 * A3}{A}$$

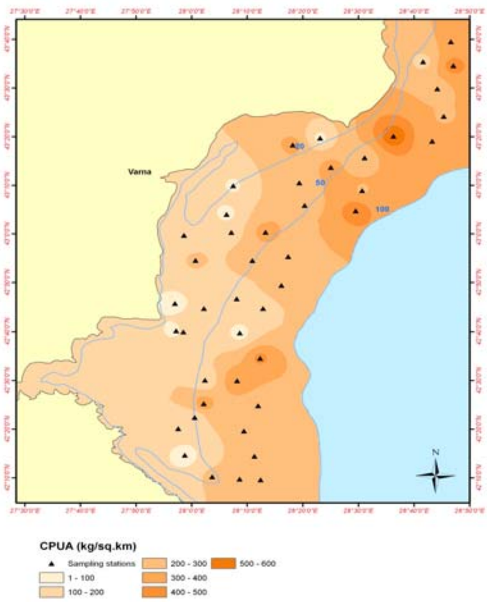
where: Ca1- catch per unit area of stratum 1 and etc., A1 – area of stratum 1 and etc., A – total area of survey region.

The total biomass in the survey area is estimated by:

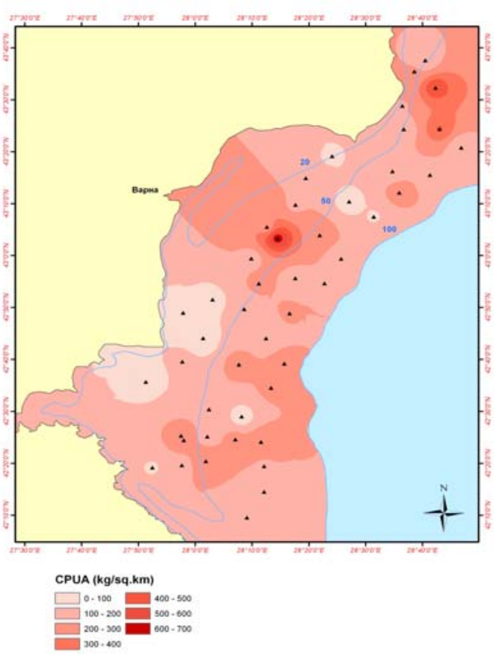
$$B = \overline{Ca}(A) * A$$

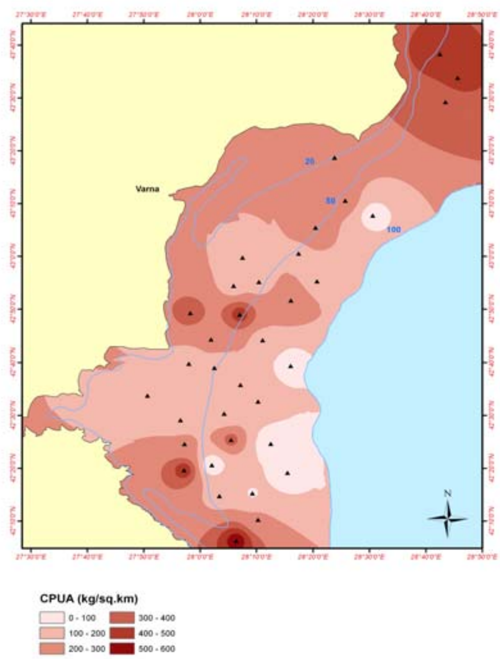
where: $\overline{Ca}(A)$- mean catch for the entire survey area, A – total area of survey region.

Because different vessels and fishing gears were employed in the Bulgarian and the Romanian areas, direct comparisons between estimated CPUAs (kg/km^2) cannot be done. Distribution of turbot CPUA from Bulgarian and Romanian surveys are shown on Fig. 4.2.5.1.1 (Panayotova et.al., 2008b, 2009, 2010) and Fig. 4.2.5.1.2. (Maximov et al, 2009; Maximov et al, 2010a, Maximov et al, 2010b; Radu et al, 2009a; Radu et al, 2009b, Radu et al, 2010a; Radu et al, 2010b), respectively.



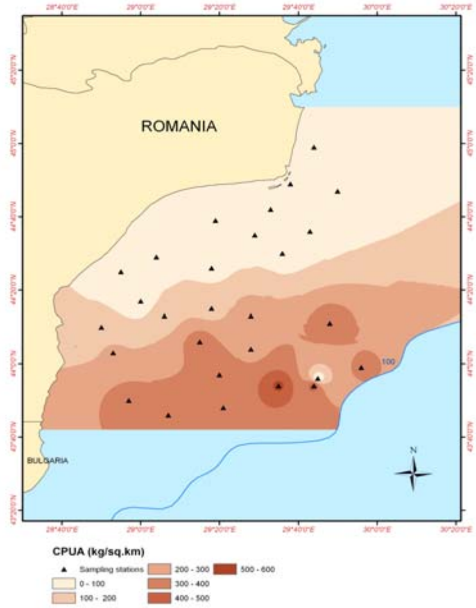
A



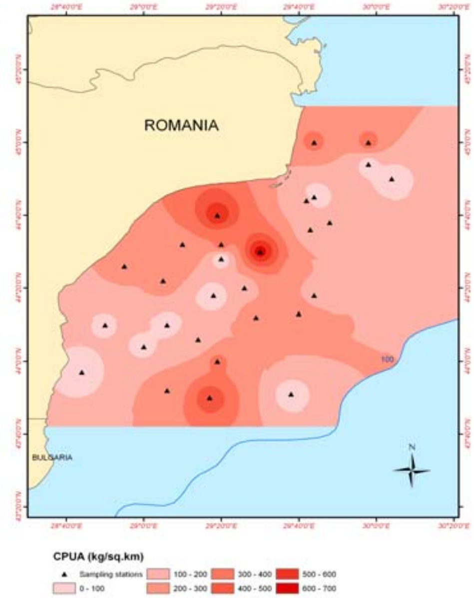


B C

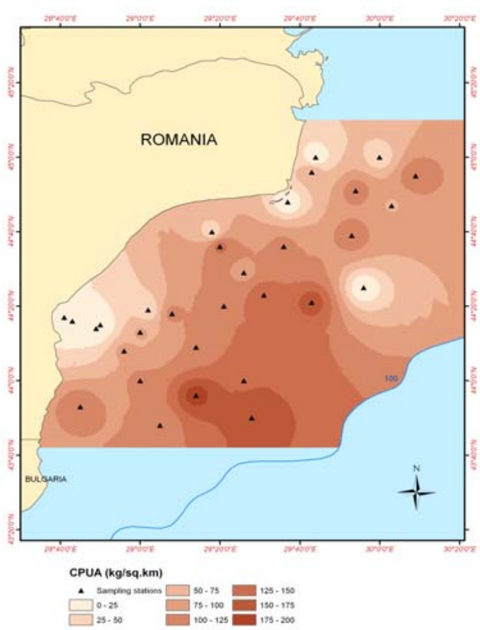
Figure 4.2.5.1.1. Distribution of turbot CPUA (kg/km^2) from surveys along the Bulgarian Black Sea coast during the spring 2008 (A), spring 2009 (B) and autumn seasons (C) in 2009 (Panayotova et.al , 2008b, Panayotova et.al,.2009, Panayotova et.al, 2010)



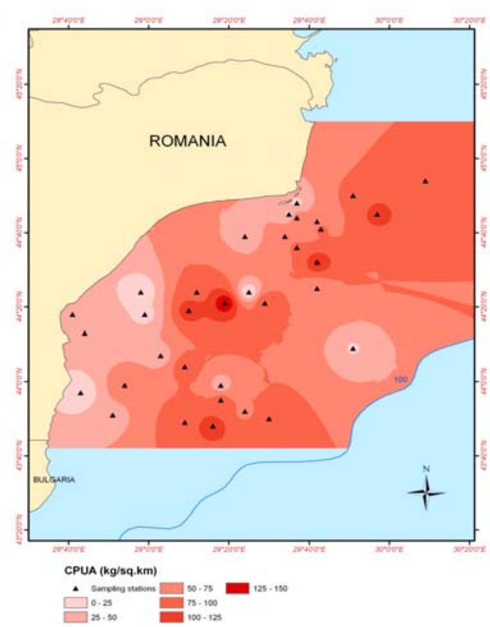
A



B



C

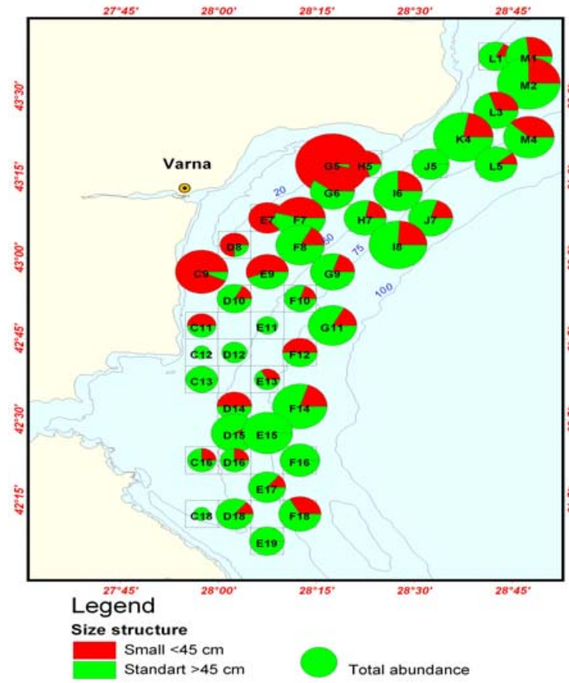


D

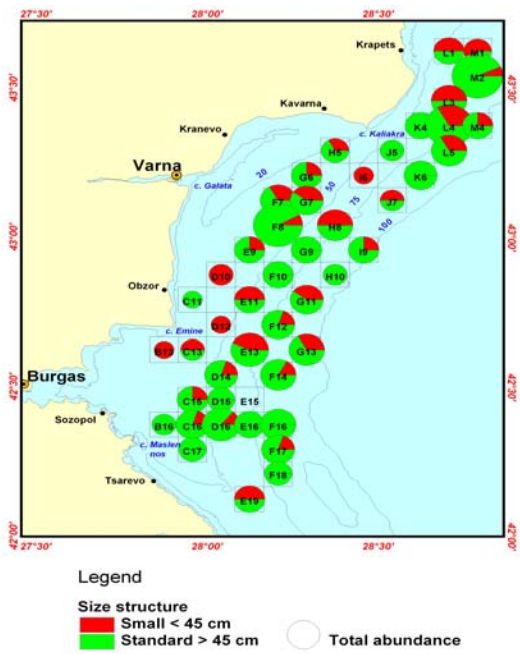
Figure 4.2.5.1.2. Distribution of turbot CPUA (kg/km^2) from surveys along the Romanian Black Sea coast during the spring (A) and autumn (B) seasons in 2008 and spring (C) and autumn (D) seasons in 2009.

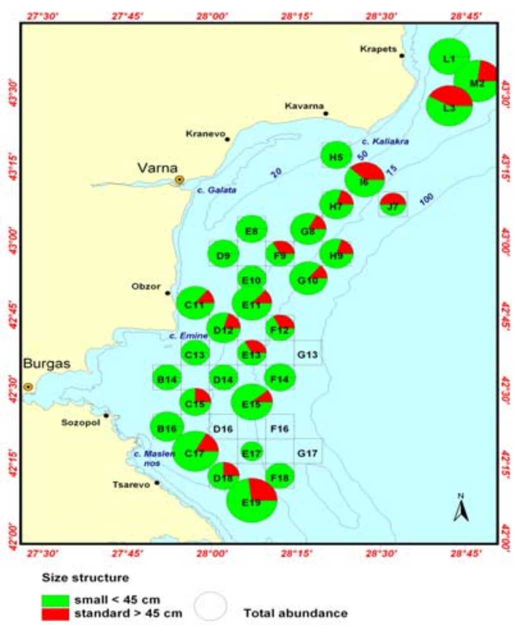
4.2.5.2 Geographical distribution patterns

The species is distributed all along the continental shelf of the Black Sea (GFCM GSA 29), with the largest abundance in the depth range between 50 – 75 m (Panayotova et.al., 2008b, 2009, 2010). The species is concentrated in the coastal area up to 40 m during the spawning period in spring and after that spreads in the deeper waters for feeding (Fig. 4.2.5.2.1).



A



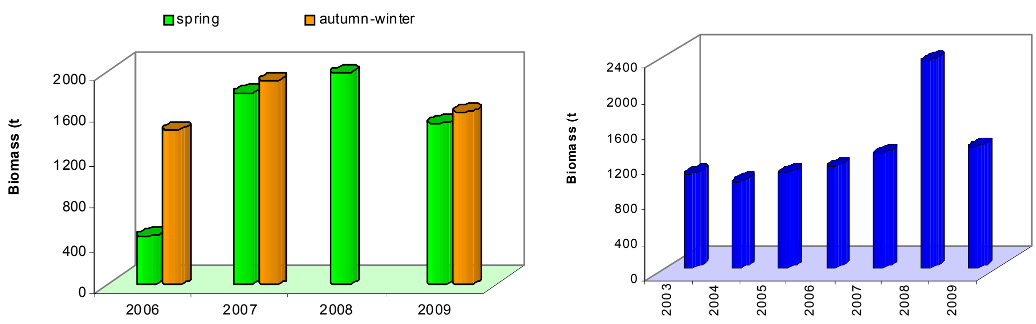


B C

Figure 4.2.5.2.1. Size distribution of turbot in 2008 (A) and spring (B) and autumn (C) season of 2009 during the surveys in the Bulgarian Black Sea area (Panayotova et.al , 2008b, Panayotova et.al,.2009, Panayotova et.al, 2010).

4.2.5.3 Trends in abundance and biomass

Fishery independent information regarding the state of the turbot was derived from the national surveys in Bulgaria (Panayotova et.al., 2006, 2007a, 2007b, 2008a, 2008b, 2009, 2010) and Romania (Maximov et al, 2009; Maximov et al, 2010a, Maximov et al, 2010b; Radu et al, 2009a; Radu et al, 2009b, Radu et al, 2010a; Radu et al, 2010b). Fig. 4.2.5.3.1 shows the trends in the biomass index in Bulgaria (A) and in Romania (B). The biomass indices show similar trends and values in the Bulgarian and in the Romanian areas.

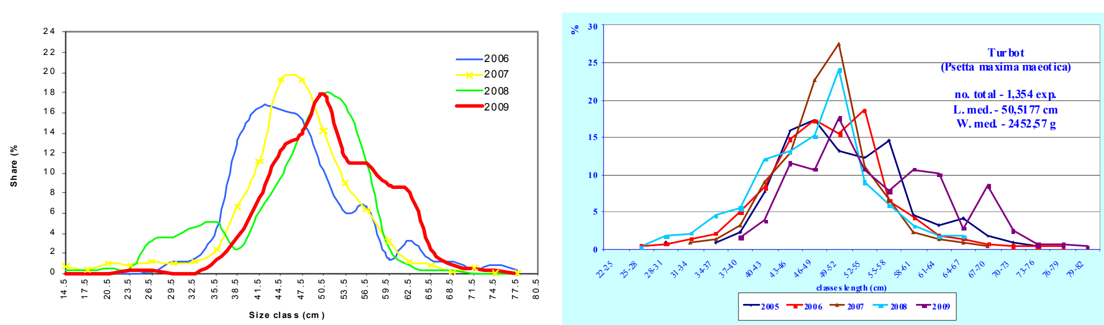


A B

Fig. 4.2.5.3.1. Biomass indices derived from national surveys in Bulgaria (A) and Romania (B) for turbot in the Black Sea.

4.2.5.4 Trends in abundance by length and age

STECF SG- RST 10-03 analyzed the available data of size composition from surveys in Bulgarian (Panayotova et.al., 2006, 2007a, 2007b, 2008a, 2008b, 2009, 2010) and Romanian waters (Maximov et al, 2009; Maximov et al, 2010a, Maximov et al, 2010b; Radu et al, 2009a; Radu et al, 2009b, Radu et al, 2010a; Radu et al, 2010b), which are consistent during the period 2006 - 2009 (Fig. 4.2.5.4.1, A, B).



A B

Figure 4.2.5.4.1. Length frequency composition of turbot catches during the surveys for Bulgaria (A) and Romania (B) during the period 2005 – 2009.

The following figures (Fig. 4.2.5.4.2. and Fig. 4.2.5.4.3.) display the abundance of turbot by age groups in the Bulgarian area (Panayotova et.al., 2006, 2007a, 2007b, 2008a, 2008b, 2009, 2010) in 2006 – 2009, and in the Romanian area (Maximov et al, 2009; Maximov et al, 2010a, Maximov et al, 2010b; Radu et al, 2009a; Radu et al, 2009b, Radu et al, 2010a; Radu et al, 2010b) in 2003-2009.

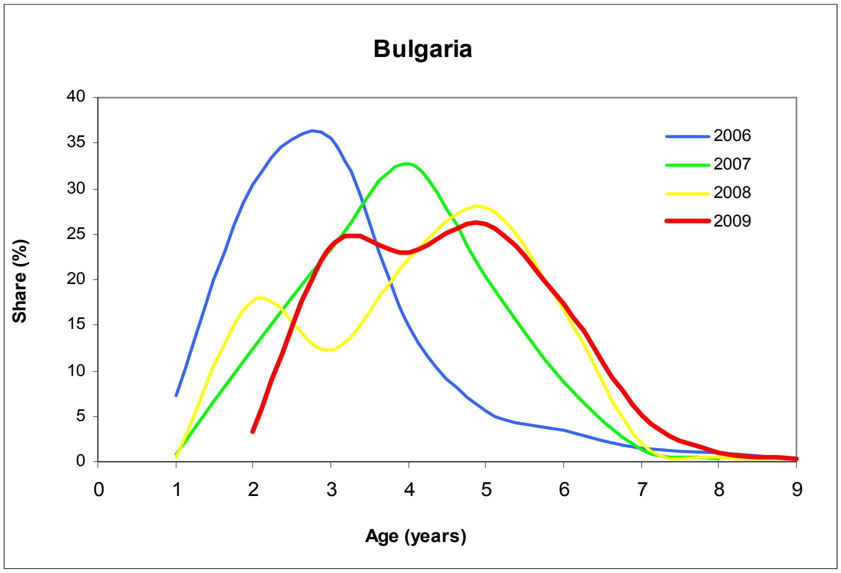
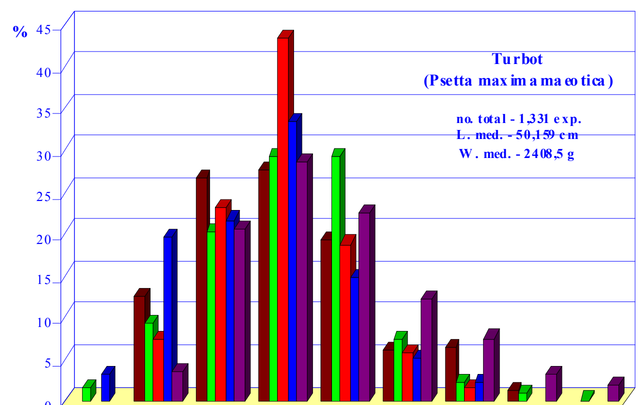


Figure 4.2.5.4.2. Age structure of turbot catches during the surveys in the Bulgarian Black Sea area during the period 2006 – 2009.



	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years
2005		12,6	26,7	27,6	19,4	6	6,5	1,2	
2006	1,4	9,3	20,2	29,3	29,3	7,3	2,2	0,9	0,1
2007		7,2	23,2	43,6	18,8	5,6	1,6		
2008	3,1	19,7	21,7	33,4	14,8	5,2	2,1		
2009		3,4	20,5	28,7	22,5	12,3	7,5	3,1	2

Figure 4.2.5.4.3. Age structure of turbot catches during the surveys in the Romanian Black Sea area during the period 2005 – 2009.

4.2.5.5 Trends in growth

No analyses were conducted.

4.2.5.6 Trends in maturity

STECF SG- RST 10-03 agreed to use in the assessment the proportion of mature turbot at age compiled from recent data – Fig. 4.2.5.6.1.

Age	1	2	3	4	5	6	7	8	9	10
% Mature	0	0	0.45	0.7	0.95	1	1	1	1	1

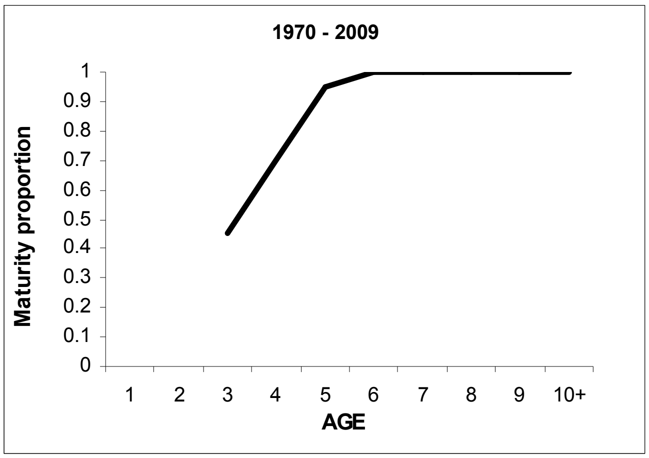


Figure. 4.2.5.6.1. Maturity ogive of turbot during the period 1970 - 2009.

4.2.6 Assessment of historic stock parameters

4.2.6.1 Justification

The data (1970-2009) of landings, catch at ages, weights and maturity at age are considered appropriate for assesseng the stock using XSA. Turkish CPUE and Bulgarian survey data were added to the Romanian and Ukrainean trawl survey data, used for tunning in previous analyses by SG-MED 09-01 (Daskalov et al., 2009).

4.2.6.2 Input parameters

Recent data from national statistics by countries for the period 1988 – 2009 were added to the historic catch at age data set compiled during the previous meetings from Prodanov et al. (1997) for the period 1970 – 1988. The catch at age data was corrected to the official landings (SOP corrections). They do represent officially reported landings and do not include any discards and unreported catches.

Assessment and qualitative assumptions about the IUU (Illegal, Unregulated and Unreported) fishing of turbot were made and rates of the Potential Unreported Catch in 2002-2009 were estimated as a proportion between Turkish catch in 1993-2001 and 2009-2010, which then was added to the officially reported catch.

The mean weights at ages in the stock for the period 1989-2009 were assumed equal to the catch weights at age in the landings due to lack of data. Theoretical weights (Ivanov, Karapetkova, 1979) were used to estimate stock biomass in 1970 – 1988.

An average natural mortality (M) of 0.19 is applied in all ages and years.

The XSA was tuned with 4 series of CPUE from Bulgarian, Romanian, Ukrainean and Turkish fleet, ages 2-10+ over the period 1987-2009.

Trends in the CPUE series are shown below in Fig. 4.2.6.2.1, Fig. 4.2.6.2.2, Fig. 4.2.6.2.3 and Fig. 4.2.6.2.4. Romanian and Ukrainian CPUE of the most abundant age groups 2-5 slightly increases in recent years and Bulgarian and Turkish CPUE – slightly decrease respectively.

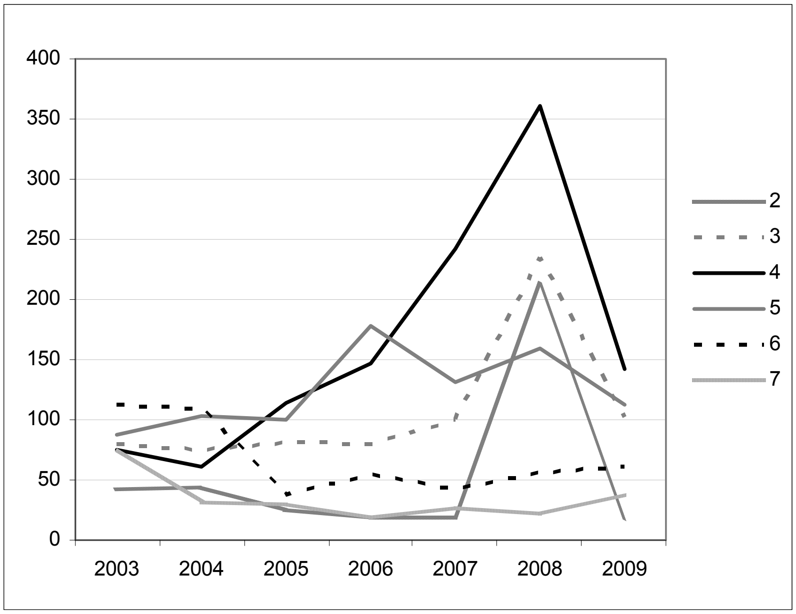


Fig. 4.2.6.2.1.Turbot in the Black Sea. Trends in the Romanian survey CPUE series at age.

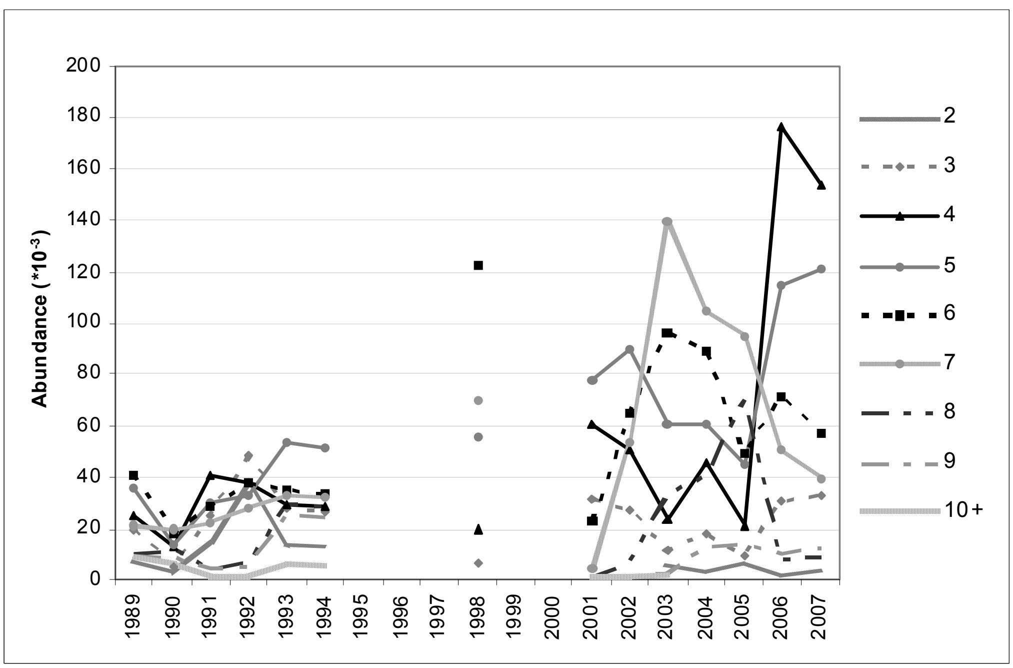


Fig. 4.2.6.2.2.Turbot in the Black Sea. Trends in the Ukrainian survey CPUE series at age.

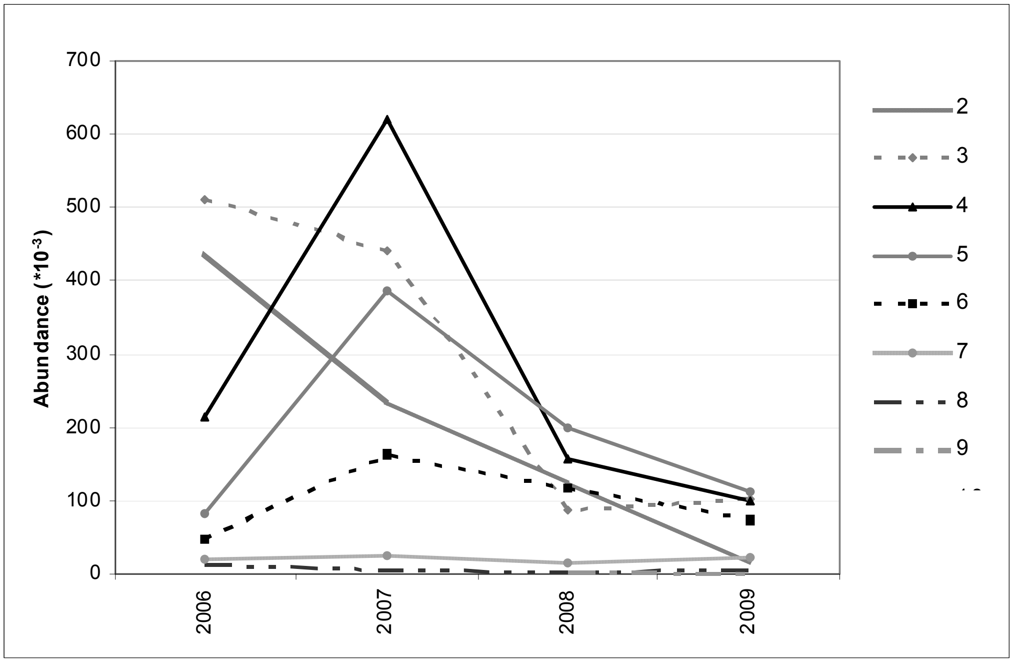


Fig. 4.2.6.2.3.Turbot in the Black Sea. Trends in the Bulgarian survey CPUE series at age.

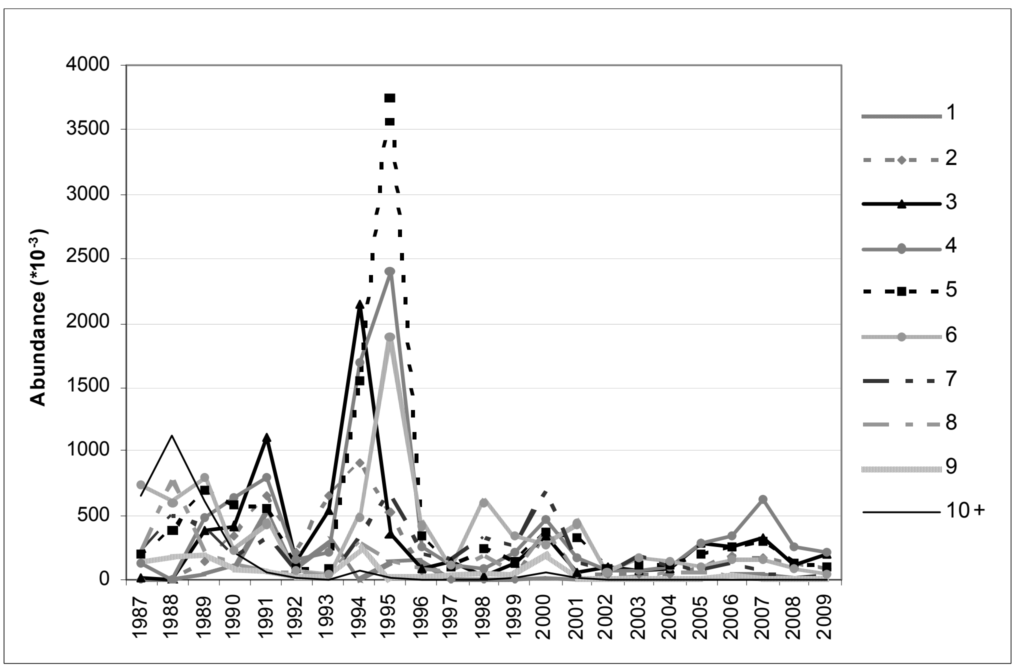


Fig. 4.2.6.2.4.Turbot in the Black Sea. Trends in the Turkish survey CPUE series at age.

Table 4.2.6.2.1 presentS the input parameters for the XSA.

Table 4.2.6.2.1. Turbot in the Black Sea 1970-2009. XSA input parameters.

	BLACK	SEA	TURBOT	1970 - 2009

Catch numbers at age (Numbers*10^3)

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	
	AGE										
	1	0	0	0	0	0	0	0	0	0	0
	2	65	2	2	3	2	0	27	22	21	3
	3	319	42	70	45	6	10	84	51	61	145
	4	155	384	48	60	9	28	34	24	47	103
	5	487	177	194	267	47	132	101	78	185	396
	6	280	167	200	229	108	91	90	99	127	324
	7	212	126	168	201	107	58	63	94	94	246
	8	76	37	69	75	38	18	19	31	29	76
	9	34	15	27	33	23	7	12	26	18	50
	10+	37	14	31	48	42	9	33	68	30	105
TOTALNUM	1665	964	808	961	382	353	463	493	612	1449	
TONSLAND	5273	3052	3049	3705	1696	1273	1584	2012	2160	5447	
SOPCOF%	100	100	100	100	100	100	100	100	100	100	

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	
	AGE										
	1	0	0	0	0	0	0	0	0	0	4
	2	13	19	0	0	0	0	0	0	0	12
	3	75	80	124	161	62	1	0	1	0	33
	4	41	26	74	101	57	3	0	10	0	41
	5	160	81	216	383	52	5	6	15	23	59
	6	190	145	184	217	86	10	7	55	35	68
	7	145	178	185	196	92	19	15	16	29	35
	8	48	97	82	79	76	9	0	16	45	17
	9	25	54	76	72	52	15	3	10	10	16
	10+	51	89	169	153	138	33	39	49	66	52
TOTALNUM	747	770	1110	1363	615	95	72	171	209	335	
TONSLAND	2843	3276	4662	5307	2852	527	428	849	1116	1452	
SOPCOF%	100	100	100	100	100	100	100	100	100	100	

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
	AGE										
	1	20	55	18	201	1	19	76	0	0	0
	2	56	71	43	436	123	67	38	0	0	0
	3	69	121	29	366	283	47	40	62	9	69
	4	106	88	30	151	224	309	129	48	26	113
	5	96	60	17	63	204	483	167	43	73	75
	6	37	47	13	26	63	245	208	50	175	182
	7	30	36	15	15	45	86	96	68	96	145
	8	21	8	10	15	39	19	42	32	54	25
	9	13	6	2	11	34	2	10	13	11	13
	10+	36	6	2	3	10	2	0	3	0	6
0TOTALNUM	484	498	180	1287	1026	1280	808	319	444	628	
TONSLAND	1392	935	438	1601	2139	2924	2031	1014	1574	1933	
SOPCOF	%	99	98	100	100	100	100	101	100	100	100

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
	1	4	0	0	1	1	2	11	14	4	0
	2	110	28	32	9	7	27	51	56	51	29
	3	98	42	62	15	18	80	69	104	55	76
	4	132	131	47	14	23	82	93	198	124	85
	5	107	244	55	24	28	57	69	95	79	55
	6	78	319	38	34	31	27	42	49	53	32
	7	197	102	27	37	21	23	36	18	28	40
	8	110	22	2	6	11	15	7	2	10	7
	9	57	3	0	0	1	1	9	2	2	1
	10+	17	8	1	0	0	0	0	0	1	0
TOTALNUM	910	898	264	142	143	314	387	539	406	325	
TONSLAND	2776	2522	592	408	425	726	959	1030	811	706	
SOPCOF	%	103	100	100	100	103	100	100	96	96	100

Catch weights at age (kg)

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	
	AGE										
	1	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614
	2	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083
	3	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646
	4	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292
	5	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004
	6	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731
	7	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456
	8	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17
	9	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876
	10+	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458
SOPCOFAC	0.9999	1.0001	0.9999	1.0001	0.9998	1.0001	1.0003	1.0002	1.0001	1	

	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	AGE										
	1	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.5
	2	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1
	3	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.4
	4	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	1.8
	5	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	2.2
	6	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.3
	7	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4

	8	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.3
	9	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	6.6
	10+	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	12.117
SOPCOFAC	1.0001	1.0002	0.9999	1.0001	1.0001	1.0002	0.9991	0.9995	1.0004	1.0001	

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	1	0.457	0.383	0.727	0.453	0.6	0.09	0.417	0.417	0.417	0.417
	2	0.73	0.777	0.947	0.893	0.76	0.72	0.822	0.822	0.822	0.822
	3	1.247	1.153	1.427	1.1	1.07	0.953	1	1	1.3	1.3
	4	1.777	1.71	1.997	1.543	1.593	1.57	1.6	1.6	1.7	1.7
	5	2.16	2.12	2.647	2.087	2.083	2.22	2.1	2.1	2.2	2.2
	6	3.243	3.03	3.907	2.963	2.597	2.993	2.8	2.8	3.1	3.1
	7	3.9	4.257	5.283	4.443	4.2	4.423	4.3	4.3	4.3	4.3
	8	5.447	5.467	6.3	5.82	5.9	6	6	6	6	6
	9	6.5	6.6	8.8	8.34	8.3	8.5	9.5	9.5	7	7
10+	12.278	12.352	9.537	9.369	9.473	9.5	10.314	10.5	10.314	9.5	
SOPCOFAC	0.9875	0.982	0.9999	1.0002	1.0001	1	1.0124	1	0.9999	1	

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
	1	0.18	0.417	0.417	0.477	0.486	0.16	0.621	0.291	0.213	0.01
	2	0.43	0.822	0.852	0.793	0.973	0.843	0.999	0.794	0.571	0.66
	3	1.227	1.3	1.283	1.292	1.429	1.321	1.507	1.4	1.356	1.155
	4	1.567	1.7	1.938	1.975	1.953	1.938	2.114	1.891	1.791	1.749
	5	2.223	2.3	2.532	2.4	2.517	2.545	2.68	2.441	2.42	2.423
	6	2.87	3.1	3.197	3.116	3.183	3.436	3.501	3.119	3.001	3.415
	7	3.913	4.1	4.117	4.078	4.238	4.388	4.467	4.706	4.015	4.197
	8	5.233	5.7	5.4	5.4	5.796	5.78	5.828	6.06	4.694	5.192
	9	6.62	9.5	6.6	6.6	6.8	7.5	7.4	7.5	5.697	6.323
	10+	8.321	12.667	10.25	10	10.314	9.842	10.314	9	6.643	9
SOPCOFAC	1.0268	1.0031	0.9997	1.0015	1.031	0.9987	1.0021	0.9631	0.9595	0.9996	

Stock weights at age (kg)

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	
	AGE										
	1	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614
	2	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083
	3	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646
	4	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292
	5	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004
	6	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731
	7	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456
	8	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17
	9	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876
	10+	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.5
2	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1
3	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.4
4	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	1.8
5	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	2.2
6	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.3
7	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4
8	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.3
9	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	6.6
10+	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	12.117

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	0.457	0.383	0.727	0.453	0.6	0.09	0.614	0.614	0.614	0.614
2	0.73	0.777	0.947	0.893	0.76	0.72	1.083	1.083	1.083	1.083
3	1.247	1.153	1.427	1.1	1.07	0.953	1	1	1.3	1.3
4	1.777	1.71	1.997	1.543	1.593	1.57	1.6	1.6	1.7	1.7
5	2.16	2.12	2.647	2.087	2.083	2.22	2.1	2.1	2.2	2.2
6	3.243	3.03	3.907	2.963	2.597	2.993	2.8	2.8	3.1	3.1
7	3.9	4.257	5.283	4.443	4.2	4.423	4.3	4.3	4.3	4.3
8	5.447	5.467	6.3	5.82	5.9	6	6	6	6	6
9	6.5	6.6	8.8	8.34	8.3	8.5	9.5	9.5	7	7
10+	12.278	12.352	9.537	9.369	9.473	9.5	7.458	10.5	10.314	9.5

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	0.18	0.614	0.614	0.614	0.486	0.16	0.621	0.291	0.213	0.01
2	1.083	1.083	0.852	0.793	0.973	0.843	0.999	0.794	0.571	0.66
3	1.227	1.3	1.283	1.292	1.429	1.321	1.507	1.4	1.356	1.155
4	1.567	1.7	1.938	1.975	1.953	1.938	2.114	1.891	1.791	1.749
5	2.223	2.3	2.532	2.4	2.517	2.545	2.68	2.441	2.42	2.423
6	2.87	3.1	3.197	3.116	3.183	3.436	3.501	3.119	3.001	3.415
7	3.913	4.1	4.117	4.078	4.238	4.388	4.467	4.706	4.015	4.197
8	5.233	5.7	5.4	5.4	5.796	5.78	5.828	6.06	4.694	5.192
9	6.62	9.5	6.6	6.6	6.8	7.5	7.4	7.5	5.697	6.323
10+	8.321	12.667	10.25	10	7.458	9.842	7.458	9	6.643	0.01

Natural Mortality (M) at age

FOR ALL YEARS DURING THE PERIOD 1970 - 2009

AGE	
1	0.19
2	0.19
3	0.19
4	0.19
5	0.19
6	0.19
7	0.19
8	0.19
9	0.19
10+	0.19

Proportion mature at age

FOR ALL YEARS DURING THE PERIOD 1970 - 2009

AGE	
1	0
2	0
3	0.45
4	0.7
5	0.95
6	1
7	1
8	1
9	1
10+	1

Proportion of M before Spawning

FOR ALL YEARS DURING THE PERIOD 1970 - 2009

AGE	
1	0.25
2	0.25
3	0.25
4	0.25
5	0.25
6	0.25
7	0.25
8	0.25
9	0.25
10+	0.25

Proportion of F before Spawning

FOR ALL YEARS DURING THE PERIOD 1970 - 2009

AGE	
1	0.5
2	0.5
3	0.5
4	0.5
5	0.5
6	0.5
7	0.5
8	0.5
9	0.5
10+	0.5

Black Sea Turbot Tunning data (effort nos at age)

RO Trawl fleet 2003 - 2009

Year/Age	2	3	4	5	6	7
2003	42.128	79.962	75.329	87.249	112.536	75.571
2004	44.134	75.775	60.611	103.477	108.773	30.69
2005	25.087	81.031	113.648	99.979	37.855	30.366
2006	18.894	78.997	146.391	177.682	54.103	18.398
2007	19.205	100.181	242.311	131.348	41.724	26.786
2008	212.502	234.076	360.282	159.646	56.092	22.653
2009	16.915	101.588	142.214	111.757	60.963	37.252

UKR Trawl survey 1989 - 2007

Year/Age	2	3	4	5	6	7	8	9	10+
1989	7.107	19.901	24.774	35.74	41.019	20.916	10.153	9.544	8.935
1990	2.862	5.128	13.117	13.833	18.126	19.676	11.686	8.705	5.843
1991	15.301	24.842	41.044	29.703	28.803	21.602	4.68	4.14	0.9
1992	36.745	48.051	37.772	33.147	38.029	28.008	6.424	5.396	1.028
1993	14.045	27.579	29.367	53.371	34.729	33.197	29.367	25.026	5.618
1994	13.487	26.484	28.201	51.252	33.35	31.879	28.201	24.032	5.395
1995	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-
1998	-	6.453	19.359	55.497	122.932	70.339	37.105	10.97	-
1999	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-
2001	10.23	31.56	60.944	77.703	22.854	4.571	0.653	0.653	0.653
2002	-	27.166	50.198	89.765	64.962	53.151	6.791	1.476	0.886
2003	5.976	11.578	23.53	60.505	95.986	139.684	33.24	1.867	1.12
2004	3.219	18.509	45.968	60.233	89.022	104.555	40.844	12.845	-
2005	6.397	9.5	20.993	45.174	49.18	95.172	70.173	13.611	3.23
2006	1.389	30.567	176.456	114.858	71.323	50.482	7.873	10.189	-
2007	3.445	33.159	153.739	121.441	56.845	39.619	9.043	12.058	1.292

BG Trawl fleet 2006 - 2009

Year/Age	2	3	4	5	6	7	8	9
2006	120.507	140.377	58.971	22.435	13.461	5.769	3.846	1.282
2007	89.56	168.174	236.837	147.277	62.692	9.951	1.99	-
2008	126.058	87.693	158.943	199.136	118.751	14.615	3.654	1.827
2009	14.595	102.163	99.918	113.39	75.219	22.453	4.491	1.123

TR CPUE 1987- 2009

Year/Age	1	2	3	4	5	6	7	8	9	10+
1987	0.092	0.916	18.532	129.699	196.87	745.774	217.71	213.077	134.332	660.07
1988	0.113	1.134	1.134	4.535	391.071	591.896	489.732	764.535	172.639	1113.305
1989	43.444	138.231	387.046	481.833	695.104	797.79	406.794	197.473	185.624	616.115
1990	122.742	342.494	418.174	642.325	580.063	227.123	179.347	127.157	79.348	218.478
1991	506.2	649.473	1109.943	805.063	554.942	432.242	334.404	77.299	56.179	56.179
1992	92.574	223.13	152.354	154.896	90.009	70.447	79.471	51.77	11.874	12.824
1993	298.977	648.313	544.021	223.945	94.396	38.474	21.85	21.833	17.024	4.826
1994	5.161	922.426	2132.378	1687.02	1539.339	472.902	335.466	296.758	252.89	77.528
1995	145.101	516.782	361.808	2395.367	3740.039	1897.558	669.31	144.157	18.803	18.803
1996	156.05	78.025	82.681	264.558	343.149	427.034	197.326	86.317	20.318	0.022
1997	0.023	0.023	139.883	109.442	97.846	113.066	154.379	72.478	30.441	7.248
1998	0.034	0.034	30.408	87.61	249.865	598.528	329.836	186.081	38.047	0.034
1999	0.019	0.019	133.808	218.958	145.972	352.766	279.78	48.657	24.329	12.164
2000	12.917	383.211	342.35	460.973	374.857	273.674	687.416	385.656	198.216	60.334

2001	0.014	38.598	57.724	180.602	335.751	438.496	140.997	30.065	3.509	10.527
2002	0.016	50.259	97.461	73.81	86.928	60.599	43.056	3.561	0.774	0.929
2003	7.082	45.008	78.459	73.136	122.406	173.125	185.598	31.039	1.744	1.046
2004	17.923	46.951	93.92	100.717	119.933	144.84	99.376	53.325	6.105	0.045
2005	5.503	95.163	285.551	292.425	203.785	97.917	80.789	53.536	4.658	1.5
2006	42.012	195.419	260.042	348.915	254.72	155.467	133.174	25.655	33.284	0.037
2007	44.048	174.978	328.102	622.842	299.856	153.438	55.696	7.264	7.077	0.758
2008	12.22	128.948	116.154	262.842	129.341	93.573	17.529	5.551	0.802	0.028
2009	0.023	81.9	206.137	217.242	106.886	47.89	34.009	0.023	0.023	0.023

Table 2.4.1.2.2 present the input parameters for the XSA version, including correction of landings and catch-at-age data with estimates of IUU catch in 2002-2009. For this assessment is used the same tuning series (Table 2.4.1.2.1)

Table 2.4.1.2.2. Turbot in the Black Sea 1970-2009. XSA input parameters with estimates of IUU catch.

BLACK SEA TURBOT 1970 – 2009 with IUU catch in 2002 - 2009

Catch numbers at age (Numbers*10^3)

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	
	AGE										
	1	0	0	0	0	0	0	0	0	0	0
	2	65	2	2	3	2	0	27	22	21	3
	3	319	42	70	45	6	10	84	51	61	145
	4	155	384	48	60	9	28	34	24	47	103
	5	487	177	194	267	47	132	101	78	185	396
	6	280	167	200	229	108	91	90	99	127	324
	7	212	126	168	201	107	58	63	94	94	246
	8	76	37	69	75	38	18	19	31	29	76
	9	34	15	27	33	23	7	12	26	18	50
	10+	37	14	31	48	42	9	33	68	30	105
TOTALNUM	1665	964	808	961	382	353	463	493	612	1449	
TONSLAND	5273	3052	3049	3705	1696	1273	1584	2012	2160	5447	
SOPCOF	%	100	100	100	100	100	100	100	100	100	100

	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE											
	1	0	0	0	0	0	0	0	0	0	4
	2	13	19	0	0	0	0	0	0	0	12
	3	75	80	124	161	62	1	0	1	0	33
	4	41	26	74	101	57	3	0	10	0	41
	5	160	81	216	383	52	5	6	15	23	59
	6	190	145	184	217	86	10	7	55	35	68
	7	145	178	185	196	92	19	15	16	29	35
	8	48	97	82	79	76	9	0	16	45	17
	9	25	54	76	72	52	15	3	10	10	16
	10+	51	89	169	153	138	33	39	49	66	52
TOTALNUM	747	770	1110	1363	615	95	72	171	209	335	
TONSLAND	2843	3276	4662	5307	2852	527	428	849	1116	1452	
SOPCOF	%	100	100	100	100	100	100	100	100	100	100

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	1	20	55	18	201	1	19	76	0	0	0
	2	56	71	43	436	123	67	38	0	0	0
	3	69	121	29	366	283	47	40	62	9	69
	4	106	88	30	151	224	309	129	48	26	113
	5	96	60	17	63	204	483	167	43	73	75
	6	37	47	13	26	63	245	208	50	175	182
	7	30	36	15	15	45	86	96	68	96	145
	8	21	8	10	15	39	19	42	32	54	25
	9	13	6	2	11	34	2	10	13	11	13
	10+	36	6	2	3	10	2	0	3	0	6
TOTALNUM	484	498	180	1287	1026	1280	808	319	444	628	
TONSLAND	1392	935	438	1601	2139	2924	2031	1014	1574	1933	
SOPCOF	%	99	98	100	100	100	100	101	100	100	100

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
	1	4	0	0	3	2	2	16	15	5	0
	2	110	28	80	20	13	49	76	89	70	38
	3	98	42	149	34	37	96	139	204	100	114
	4	132	131	110	28	46	141	314	461	221	141
	5	107	244	129	53	61	109	229	271	180	124
	6	78	319	90	76	73	80	130	124	113	85
	7	197	102	64	86	58	108	96	58	93	130
	8	110	22	5	16	27	75	16	11	33	27
	9	57	3	1	1	5	12	20	13	6	4
	10+	17	8	1	1	0	4	0	1	2	0
TOTALNUM	910	898	629	318	322	676	1035	1248	822	661	
TONSLAND	2776	2522	1412	943	989	2039	2737	2692	1901	1541	
SOPCOF %	103	100	101	101	101	100	102	98	99	91	

Catch weights at age (kg)

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979		AGE
	1	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	
	2	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	
	3	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	
	4	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	
	5	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	
	6	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	

	7	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456
	8	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17
	9	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876
10+	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	
SOPCOFAC	0.9999	1.0001	0.9999	1.0001	1	1	1.0003	1.0002	1.0001	1	

	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	AGE										
	1	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.5
	2	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1
	3	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.4
	4	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	1.8
	5	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	2.2
	6	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.3
	7	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4
	8	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.3
	9	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	6.6
	10+	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	12.12
SOPCOFAC	1.0001	1.0002	0.9999	1.0001	1	1	0.9991	0.9995	1.0004	1	

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	1	0.457	0.383	0.727	0.453	0.6	0.09	0.417	0.417	0.417	0.417
	2	0.73	0.777	0.947	0.893	0.76	0.72	0.822	0.822	0.822	0.822
	3	1.247	1.153	1.427	1.1	1.07	0.953	1	1	1.3	1.3
	4	1.777	1.71	1.997	1.543	1.593	1.57	1.6	1.6	1.7	1.7
	5	2.16	2.12	2.647	2.087	2.083	2.22	2.1	2.1	2.2	2.2
	6	3.243	3.03	3.907	2.963	2.597	2.993	2.8	2.8	3.1	3.1
	7	3.9	4.257	5.283	4.443	4.2	4.423	4.3	4.3	4.3	4.3
	8	5.447	5.467	6.3	5.82	5.9	6	6	6	6	6
	9	6.5	6.6	8.8	8.34	8.3	8.5	9.5	9.5	7	7
	10+	12.278	12.352	9.537	9.369	9.473	9.5	10.314	10.5	10.314	9.5
SOPCOFAC	0.9875	0.982	0.9999	1.0002	1	1	1.0124	1	0.9999	1	

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
	1	0.18	0.417	0.417	0.477	0.486	0.16	0.621	0.291	0.213	0.01
	2	0.43	0.822	0.852	0.793	0.973	0.843	0.999	0.794	0.571	0.66
	3	1.227	1.3	1.283	1.292	1.429	1.321	1.507	1.4	1.356	1.155
	4	1.567	1.7	1.938	1.975	1.953	1.938	2.114	1.891	1.791	1.749
	5	2.223	2.3	2.532	2.4	2.517	2.545	2.68	2.441	2.42	2.423
	6	2.87	3.1	3.197	3.116	3.183	3.436	3.501	3.119	3.001	3.415
	7	3.913	4.1	4.117	4.078	4.238	4.388	4.467	4.706	4.015	4.197
	8	5.233	5.7	5.4	5.4	5.796	5.78	5.828	6.06	4.694	5.192
	9	6.62	9.5	6.6	6.6	6.8	7.5	7.4	7.5	5.697	6.323
	10+	8.321	12.667	10.25	10	10.31	9.842	10.314	9	6.643	0.01
SOPCOFAC	1.0268	1.0031	1.0104	1.0124	1.009	1.004	1.0157	0.9844	0.9883	0.907	

Stock weights at age (kg)

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	
	AGE										
	1	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614
	2	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083
	3	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646
	4	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292
	5	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004
	6	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731
	7	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456
	8	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17
	9	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876
	10+	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458

	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	AGE										
	1	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.5
	2	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1
	3	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.4
	4	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	1.8
	5	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	2.2
	6	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.3
	7	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4
	8	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.3
	9	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	6.6
	10+	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	12.12

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	1	0.457	0.383	0.727	0.453	0.6	0.09	0.614	0.614	0.614	0.614
	2	0.73	0.777	0.947	0.893	0.76	0.72	1.083	1.083	1.083	1.083
	3	1.247	1.153	1.427	1.1	1.07	0.953	1	1	1.3	1.3
	4	1.777	1.71	1.997	1.543	1.593	1.57	1.6	1.6	1.7	1.7
	5	2.16	2.12	2.647	2.087	2.083	2.22	2.1	2.1	2.2	2.2
	6	3.243	3.03	3.907	2.963	2.597	2.993	2.8	2.8	3.1	3.1
	7	3.9	4.257	5.283	4.443	4.2	4.423	4.3	4.3	4.3	4.3
	8	5.447	5.467	6.3	5.82	5.9	6	6	6	6	6
	9	6.5	6.6	8.8	8.34	8.3	8.5	9.5	9.5	7	7
	10+	12.278	12.352	9.537	9.369	9.473	9.5	7.458	10.5	10.314	9.5

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
	1	0.18	0.614	0.614	0.614	0.486	0.16	0.621	0.291	0.213	0.01
	2	1.083	1.083	0.852	0.793	0.973	0.843	0.999	0.794	0.571	0.66
	3	1.227	1.3	1.283	1.292	1.429	1.321	1.507	1.4	1.356	1.155
	4	1.567	1.7	1.938	1.975	1.953	1.938	2.114	1.891	1.791	1.749
	5	2.223	2.3	2.532	2.4	2.517	2.545	2.68	2.441	2.42	2.423
	6	2.87	3.1	3.197	3.116	3.183	3.436	3.501	3.119	3.001	3.415
	7	3.913	4.1	4.117	4.078	4.238	4.388	4.467	4.706	4.015	4.197
	8	5.233	5.7	5.4	5.4	5.796	5.78	5.828	6.06	4.694	5.192
	9	6.62	9.5	6.6	6.6	6.8	7.5	7.4	7.5	5.697	6.323
	10+	8.321	12.667	10.25	10	7.458	9.842	7.458	9	6.643	0.01

Natural Mortality (M) at age

FOR ALL YEARS DURING THE PERIOD 1970 - 2009

AGE	
1	0.19
2	0.19
3	0.19
4	0.19
5	0.19
6	0.19
7	0.19
8	0.19
9	0.19
10+	0.19

Proportion mature at age

FOR ALL YEARS DURING THE PERIOD 1970 - 2009

AGE	
1	0
2	0
3	0.45
4	0.7
5	0.95
6	1
7	1
8	1
9	1
10+	1

Proportion of M before Spawning

FOR ALL YEARS DURING THE PERIOD 1970 - 2009

AGE	
1	0.25
2	0.25
3	0.25
4	0.25
5	0.25
6	0.25
7	0.25
8	0.25
9	0.25
10+	0.25

Proportion of F before Spawning

FOR ALL YEARS DURING THE PERIOD 1970 - 2009

AGE	
1	0.5
2	0.5
3	0.5
4	0.5
5	0.5
6	0.5
7	0.5
8	0.5
9	0.5
10+	0.5

Black Sea Turbot Tunning data (effort nos at age)

RO Trawl fleet 2003 - 2009

Year/Age	2	3	4	5	6	7
2003	42.128	79.962	75.329	87.249	112.536	75.571
2004	44.134	75.775	60.611	103.477	108.773	30.69
2005	25.087	81.031	113.648	99.979	37.855	30.366
2006	18.894	78.997	146.391	177.682	54.103	18.398
2007	19.205	100.181	242.311	131.348	41.724	26.786
2008	212.502	234.076	360.282	159.646	56.092	22.653
2009	16.915	101.588	142.214	111.757	60.963	37.252

UKR Trawl survey 1989 - 2007

Year/Age	2	3	4	5	6	7	8	9	10+
1989	7.107	19.901	24.774	35.74	41.019	20.916	10.153	9.544	8.935
1990	2.862	5.128	13.117	13.833	18.126	19.676	11.686	8.705	5.843
1991	15.301	24.842	41.044	29.703	28.803	21.602	4.68	4.14	0.9
1992	36.745	48.051	37.772	33.147	38.029	28.008	6.424	5.396	1.028
1993	14.045	27.579	29.367	53.371	34.729	33.197	29.367	25.026	5.618
1994	13.487	26.484	28.201	51.252	33.35	31.879	28.201	24.032	5.395
1995	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-
1998	-	6.453	19.359	55.497	122.932	70.339	37.105	10.97	-
1999	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-
2001	10.23	31.56	60.944	77.703	22.854	4.571	0.653	0.653	0.653
2002	-	27.166	50.198	89.765	64.962	53.151	6.791	1.476	0.886
2003	5.976	11.578	23.53	60.505	95.986	139.684	33.24	1.867	1.12
2004	3.219	18.509	45.968	60.233	89.022	104.555	40.844	12.845	-
2005	6.397	9.5	20.993	45.174	49.18	95.172	70.173	13.611	3.23
2006	1.389	30.567	176.456	114.858	71.323	50.482	7.873	10.189	-

2007	3.445	33.159	153.739	121.441	56.845	39.619	9.043	12.058	1.292

BG Trawl fleet 2006 - 2009

Year/Age	2	3	4	5	6	7	8	9
2006	120.507	140.377	58.971	22.435	13.461	5.769	3.846	1.282
2007	89.56	168.174	236.837	147.277	62.692	9.951	1.99	-
2008	126.058	87.693	158.943	199.136	118.751	14.615	3.654	1.827
2009	14.595	102.163	99.918	113.39	75.219	22.453	4.491	1.123

TR CPUE 1987- 2009

Year/Age	1	2	3	4	5	6	7	8	9	10+
1987	0.092	0.916	18.532	129.699	196.87	745.774	217.71	213.077	134.332	660.07
1988	0.113	1.134	1.134	4.535	391.071	591.896	489.732	764.535	172.639	1113.305
1989	43.444	138.231	387.046	481.833	695.104	797.79	406.794	197.473	185.624	616.115
1990	122.742	342.494	418.174	642.325	580.063	227.123	179.347	127.157	79.348	218.478
1991	506.2	649.473	1109.943	805.063	554.942	432.242	334.404	77.299	56.179	56.179
1992	92.574	223.13	152.354	154.896	90.009	70.447	79.471	51.77	11.874	12.824
1993	298.977	648.313	544.021	223.945	94.396	38.474	21.85	21.833	17.024	4.826
1994	5.161	922.426	2132.378	1687.02	1539.339	472.902	335.466	296.758	252.89	77.528
1995	145.101	516.782	361.808	2395.367	3740.039	1897.558	669.31	144.157	18.803	18.803
1996	156.05	78.025	82.681	264.558	343.149	427.034	197.326	86.317	20.318	0.022
1997	0.023	0.023	139.883	109.442	97.846	113.066	154.379	72.478	30.441	7.248
1998	0.034	0.034	30.408	87.61	249.865	598.528	329.836	186.081	38.047	0.034
1999	0.019	0.019	133.808	218.958	145.972	352.766	279.78	48.657	24.329	12.164
2000	12.917	383.211	342.35	460.973	374.857	273.674	687.416	385.656	198.216	60.334
2001	0.014	38.598	57.724	180.602	335.751	438.496	140.997	30.065	3.509	10.527
2002	0.016	50.259	97.461	73.81	86.928	60.599	43.056	3.561	0.774	0.929
2003	7.082	45.008	78.459	73.136	122.406	173.125	185.598	31.039	1.744	1.046
2004	17.923	46.951	93.92	100.717	119.933	144.84	99.376	53.325	6.105	0.045
2005	5.503	95.163	285.551	292.425	203.785	97.917	80.789	53.536	4.658	1.5
2006	42.012	195.419	260.042	348.915	254.72	155.467	133.174	25.655	33.284	0.037
2007	44.048	174.978	328.102	622.842	299.856	153.438	55.696	7.264	7.077	0.758
2008	12.22	128.948	116.154	262.842	129.341	93.573	17.529	5.551	0.802	0.028
2009	0.023	81.9	206.137	217.242	106.886	47.89	34.009	0.023	0.023	0.023

4.2.6.3 Results

The WG applied the Extended Survivors Analysis (XSA, Shepherd, 1992) and the technique "shrinkage to the mean" for assessing the stock of turbot in 1970-2009.

The tuning of XSA is defined according to the default settings of the program. Catchability is set dependent on stock size for ages <3 and independent of age for ages >=5. The Romanian and Bulgarian survey data gets the majority of the weight for the calculation of the survivors at all ages and the corresponding fishing mortality. This is confirmed from the tuning diagnostics, which indicate standard errors of the log transformed catchabilities and regression parameters (slopes and r-squared) at acceptable levels. Diagnostics of the Ukraine CPUE show poor fit which contributes to the low weight it gets in the calculation of survivors and terminal fishing mortality (Tab. 4.2.6.3.1).

Fig. 4.2.6.3.1. illustrates the retrospective behaviour of the fishing mortality (average over ages 4-8), SSB and recruitment. The retrospective runs consistently underestimate F and overestimate abundance which is possibly an effect of the shrinkage of the terminal F over last 5 years.

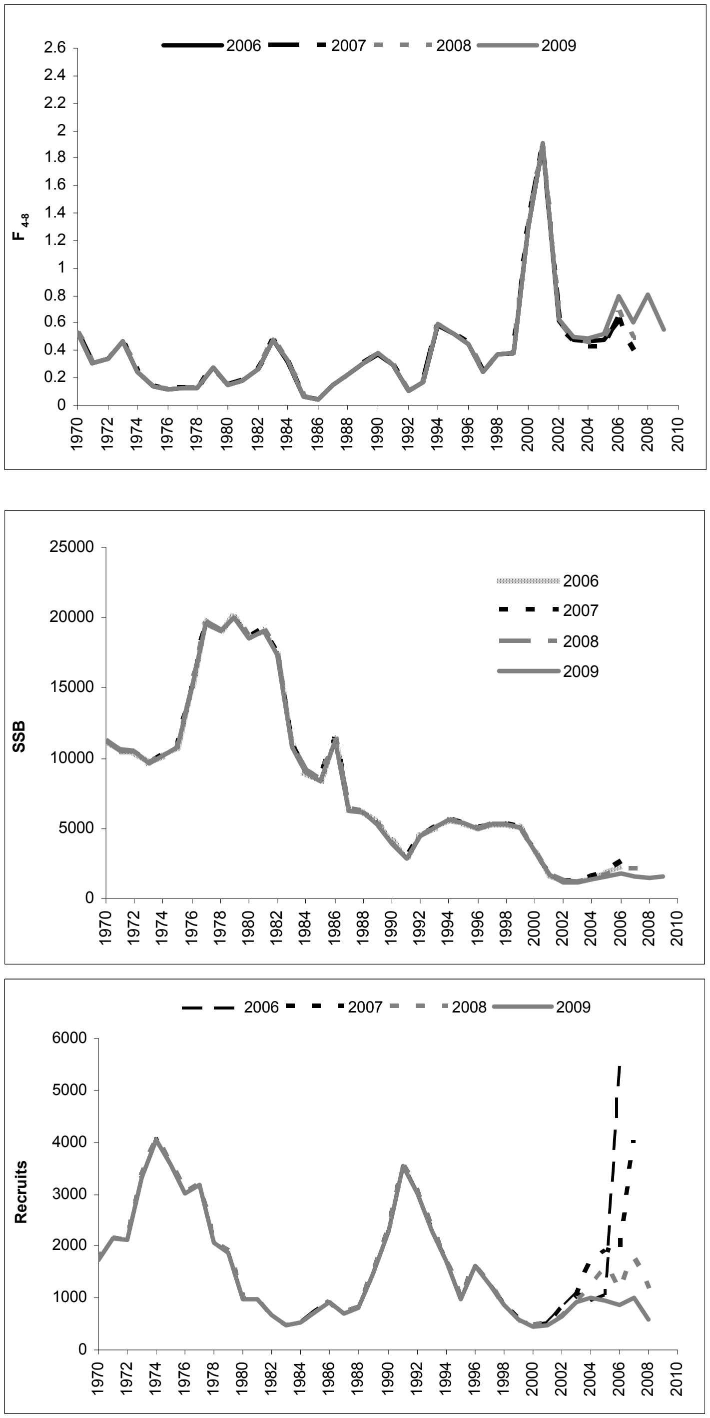


Fig. 4.2.6.3.1. Turbot in the Black Sea. Retrospective trends of the assessment parameters fishing mortality (average over ages 4-8), SSB and recruitment.

XSA outputs are listed in the Tab. 4.2.6.3.1.

Tab. 4.2.6.3.1. Turbot in the Black Sea. XSA results and diagnostics.

BLACK

SEA TURBOT 1970 - 2009

Fishing mortality (F) at age

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979			
	AGE												
	1	0	0	0	0	0	0	0	0	0	0		2
	0.0347	0.0012	0.0011	0.0021	0.0009	0.0001	0.01	0.0095	0.0089	0.0022		3	0.1653
	0.028	0.0672	0.0347	0.0045	0.0049	0.0339	0.0233	0.0333	0.0767		4	0.1343	0.3031
	0.0395	0.075	0.0087	0.0262	0.0202	0.0119	0.027	0.072		5	0.4713	0.2219	0.2436
	0.318	0.0761	0.1645	0.1233	0.0582	0.1189	0.3237		6	0.5203	0.2865	0.4142	0.5009
	0.202	0.2056	0.1596	0.1695	0.1252	0.3109		7	0.7758	0.4659	0.5177	0.9764	0.456
	0.1575	0.2128	0.2465	0.2381	0.3763		8	0.7558	0.2871	0.5006	0.4551	0.4732	0.1234
	0.0683	0.1542	0.1091	0.3052		9	0.5355	0.3147	0.3452	0.4684	0.2444	0.1359	0.1172
	0.1285	0.124	0.2791		10+	0.5355	0.3147	0.3452	0.4684	0.2444	0.1359	0.1172	0.1285
	0.124	0.2791											
FBAR 3-7		0.4134	0.2611	0.2565	0.381	0.1495	0.1117	0.1099	0.1019	0.1085	0.2319		

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989			
AGE													
	1	0	0	0	0	0	0	0	0	0	0.0028		2
	0.009	0.0266	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0001	0.0198		3	0.0598
	0.0719	0.2345	0.31	0.158	0.0032	0.0002	0.003	0.0001	0.0801		4	0.0274	0.0261
	0.0873	0.2995	0.1675	0.0093	0.0012	0.036	0.0007	0.0913		5	0.15	0.0694	0.3124
	0.8386	0.2478	0.021	0.0262	0.0748	0.1133	0.2138		6	0.2505	0.1966	0.2198	0.5874
	0.4416	0.0697	0.0361	0.33	0.2563	0.5528		7	0.2202	0.3888	0.4057	0.3824	0.5304
	0.1568	0.1356	0.1022	0.2857	0.4282		8	0.1152	0.2223	0.3094	0.3003	0.2449	0.0845
	0.0032	0.2033	0.4551	0.2631		9	0.1532	0.1813	0.2683	0.4851	0.3283	0.0684	0.0405
	0.1425	0.1946	0.2781		10+	0.1532	0.1813	0.2683	0.4851	0.3283	0.0684	0.0405	0.1425
	0.1946	0.2781											
FBAR 3-7		0.1416	0.1506	0.252	0.4836	0.3091	0.052	0.0399	0.1092	0.1312	0.2732		

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
AGE													
	1	0.0097	0.0173	0.0065	0.102	0.0004	0.0211	0.0532	0	0	0		2
	0.0534	0.0421	0.0164	0.2146	0.0825	0.0533	0.0538	0	0	0		3	0.1533
	0.1529	0.0217	0.1887	0.2084	0.0405	0.0408	0.1146	0.0094	0.0935		4	0.3931	0.2937
	0.0502	0.1473	0.1671	0.3652	0.1484	0.0622	0.0628	0.1565		5	0.315	0.4034	0.0846
	0.1433	0.302	0.6425	0.3404	0.0668	0.1247	0.2629		6	0.202	0.2486	0.1439	0.1749
	0.2038	0.7154	0.635	0.1577	0.4131	0.5132		7	0.4936	0.305	0.1168	0.2283	0.5078
	0.4719	0.6861	0.4311	0.5091	0.7173		8	0.4981	0.2478	0.1248	0.1564	1.7857	0.4069
	0.4389	0.5033	0.7342	0.2353		9	0.334	0.2582	0.0963	0.2057	0.632	0.4618	0.3906
	0.2385	0.3215	0.3615		10+	0.334	0.2582	0.0963	0.2057	0.632	0.4618	0.3906	0.2385
	0.3215	0.3615											
FBAR 3-7		0.3114	0.2807	0.0834	0.1765	0.2778	0.4471	0.3702	0.1665	0.2238	0.3487		

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	FBAR	**-**	
	AGE												
	1	0.0089	0	0	0.0017	0.0015	0.0018	0.0143	0.0155	0.0083	0.0007	0.0082	2
	0.2878	0.0853	0.093	0.0184	0.0106	0.0358	0.0739	0.0917	0.0722	0.0667	0.0769	3	0.2021
	0.1675	0.2703	0.0591	0.0479	0.1542	0.1206	0.2086	0.1232	0.1441	0.1586	4	0.2563	0.4507
	0.2818	0.0919	0.1143	0.3058	0.2674	0.5918	0.4064	0.28	0.4261	5	0.2159	1.0597	0.3407
	0.2277	0.2557	0.4592	0.4507	0.477	0.4895	0.3145	0.427	6	0.4741	2.0048	0.444	0.3637
	0.5048	0.4243	0.7304	0.6724	0.525	0.3718	0.523	7	2.0805	3.2074	1.0923	1.0371	0.3981
	0.8688	1.8215	0.7825	1.0672	0.9979	0.9492	8	3.4489	2.8328	0.9966	0.7735	1.1657	0.5437
	0.7089	0.512	1.5278	0.7873	0.9423	9	1.2864	1.905	0.569	0.3791	0.3512	0.3633	0.7318
	0.5232	0.8158	0.5589	0.6326	10+	1.2864	1.905	0.569	0.3791	0.3512	0.3633	0.7318	0.5232
	0.8158	0.5589											
FBAR 3-7		0.6458	1.378	0.4858	0.3559	0.2642	0.4424	0.6781	0.5465	0.5223	0.4217		

Relative F at age

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979			
	AGE												
	1	0	0	0	0	0	0	0	0	0	0		2
	0.084	0.0047	0.0043	0.0054	0.0059	0.0006	0.0912	0.0936	0.082	0.0097		3	0.3998
	0.1074	0.2622	0.0911	0.03	0.0441	0.3084	0.2284	0.3065	0.3308		4	0.3248	1.161
	0.1538	0.1968	0.0585	0.2341	0.1838	0.1166	0.2485	0.3105		5	1.1401	0.8499	0.95
	0.8346	0.5094	1.472	1.1211	0.5717	1.0959	1.3956		6	1.2586	1.0972	1.6152	1.3146
	1.3516	1.8405	1.4514	1.6641	1.154	1.3406		7	1.8768	1.7845	2.0188	2.5628	3.0506
	1.4093	1.9353	2.4192	2.195	1.6225		8	1.8283	1.0997	1.9519	1.1946	3.1653	1.1047
	0.6208	1.5131	1.0053	1.3161		9	1.2956	1.2051	1.3458	1.2293	1.6348	1.2163	1.0658
	1.2611	1.1435	1.2032										
FBAR 3-7		1.2956	1.2051	1.3458	1.2293	1.6348	1.2163	1.0658	1.2611	1.1435	1.2032		
REFMEAN		0.4134	0.2611	0.2565	0.381	0.1495	0.1117	0.1099	0.1019	0.1085	0.2319		

	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989		
											AGE		
	1	0.0001	0.0001	0	0	0	0.0002	0.0002	0.0001	0.0001	0.0103		2
	0.0633	0.1765	0.0004	0.0003	0.0006	0.0033	0.0033	0.0009	0.001	0.0725		3	0.4223
	0.4779	0.9308	0.641	0.5112	0.0617	0.0054	0.0279	0.0009	0.2932		4	0.1937	0.1732
	0.3464	0.6194	0.5421	0.1791	0.0294	0.33	0.0055	0.3341		5	1.0596	0.461	1.24
	1.7342	0.8019	0.4029	0.6576	0.6851	0.8634	0.7824		6	1.7692	1.3056	0.8725	1.2147
	1.4287	1.3408	0.9065	3.0216	1.953	2.023		7	1.5551	2.5823	1.6102	0.7907	1.7161
	3.0155	3.4011	0.9354	2.1772	1.5672		8	0.8133	1.4763	1.2281	0.6211	0.7923	1.6244
	0.0795	1.8615	3.468	0.963		9	1.0821	1.2045	1.0648	1.0032	1.0622	1.3158	1.0169
	1.305	1.4827	1.0178		10+	1.0821	1.2045	1.0648	1.0032	1.0622	1.3158	1.0169	1.305
	1.4827	1.0178											
REFMEAN		0.1416	0.1506	0.252	0.4836	0.3091	0.052	0.0399	0.1092	0.1312	0.2732		

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
	AGE												
	1	0.0312	0.0615	0.0775	0.5781	0.0016	0.0472	0.1437	0.0001	0.0001	0.0001		2
	0.1714	0.15	0.1971	1.2157	0.297	0.1192	0.1454	0.0001	0	0		3	0.4924
	0.5446	0.2598	1.0691	0.75	0.0905	0.1104	0.6882	0.0418	0.2682		4	1.2624	1.0464

	0.6019	0.8347	0.6014	0.8169	0.401	0.3734	0.2806	0.4487		5	1.0115	1.4369	1.0138
	0.8117	1.0871	1.437	0.9195	0.4014	0.5571	0.7541		6	0.6486	0.8856	1.7245	0.991
	0.7336	1.6002	1.7155	0.9474	1.8458	1.4719		7	1.5851	1.0866	1.4001	1.2936	1.8278
	1.0554	1.8536	2.5897	2.2748	2.0572		8	1.5996	0.8826	1.4957	0.8861	6.428	0.91
	1.1857	3.0236	3.2804	0.6749		9	1.0727	0.9198	1.1538	1.1652	2.2751	1.0329	1.0551
	1.4327	1.4366	1.0369		10+	1.0727	0.9198	1.1538	1.1652	2.2751	1.0329	1.0551	1.4327
	1.4366	1.0369											
REFMEAN		0.3114	0.2807	0.0834	0.1765	0.2778	0.4471	0.3702	0.1665	0.2238	0.3487		

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	MEAN	**-**
													AGE
	1	0.0137	0	0	0.0047	0.0055	0.004	0.0211	0.0284	0.0159	0.0016	0.0153	2
	0.4456	0.0619	0.1915	0.0518	0.0403	0.0809	0.109	0.1679	0.1382	0.1582	0.1548	3	0.313
	0.1215	0.5564	0.1661	0.1813	0.3484	0.1779	0.3817	0.2359	0.3418	0.3198	4	0.3969	0.3271
	0.5801	0.2583	0.4328	0.6911	0.3943	1.0829	0.7782	0.664	0.8417	5	0.3343	0.769	0.7013
	0.6397	0.9679	1.0379	0.6646	0.8729	0.9373	0.746	0.852	6	0.7342	1.4548	0.9138	1.0219
	1.911	0.9589	1.077	1.2305	1.0052	0.8817	1.0391	7	3.2216	2.3275	2.2484	2.914	1.507
	1.9637	2.6861	1.432	2.0434	2.3666	1.9473	8	5.3406	2.0557	2.0512	2.1735	4.4131	1.2289
	1.0454	0.9369	2.9253	1.8671	1.9098	9	1.992	1.3824	1.1713	1.0652	1.3295	0.8212	1.0792
	0.9574	1.5621	1.3254	1.2817	10+	1.992	1.3824	1.1713	1.0652	1.3295	0.8212	1.0792	0.9574
	1.5621	1.3254											
REFMEAN		0.6458	1.378	0.4858	0.3559	0.2642	0.4424	0.6781	0.5465	0.5223	0.4217		

Stock number at age (start of year) Numbers10^3*

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979			
	AGE												
	1	1726	2147	2111	3329	4060	3579	3020	3175	2070	1878		2
	2110	1427	1775	1746	2753	3358	2960	2497	2626	1712		3	2302
	1685	1179	1466	1441	2275	2777	2423	2045	2152		4	1356	1614
	1355	911	1171	1186	1872	2220	1958	1636		5	1425	981	985
	1077	699	960	956	1517	1814	1576		6	759	736	650	639
	648	536	674	699	1183	1332		7	431	373	457	355	320
	438	361	475	488	863		8	157	164	194	225	111	168
	309	241	307	318		9	91	61	102	97	118	57	123
	239	171	228		10+	98	56	115	139	212	78	331	621
	285	472											
TOTAL	10456	9243	8922	9985	11533	12635	13381	14107	12947	12167			

	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989		
	AGE												
	1	981	973	677	477	527	724	912	687	796	1449		2
	1553	812	805	560	394	436	599	754	568	658		3	1413
	1273	654	665	463	326	360	495	624	469		4	1648	1100
	979	427	404	327	269	298	408	516		5	1259	1326	887
	742	262	282	268	222	238	337		6	943	896	1023	536
	265	169	229	216	170	175		7	807	607	609	679	247
	141	130	182	128	109		8	490	535	340	336	383	120
	100	94	136	80		9	194	361	355	206	206	248	91
	82	64	71		10+	394	588	784	434	540	552	1086	403
	408	236		TOTAL	9682	8471	7112	5064	3691	3325	4044	3433	3539
	4101												

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
	AGE												
	1	2300	3538	3021	2279	1710	987	1617	1245	861	583		2
	1195	1884	2875	2482	1702	1414	799	1268	1030	712		3	533
	937	1494	2339	1656	1296	1108	626	1048	851		4	358	378
	665	1209	1602	1112	1029	880	462	859		5	389	200	233
	523	863	1121	638	734	684	359		6	225	235	111	177
	375	527	487	376	567	499		7	83	152	152	79	123
	253	213	214	265	310		8	59	42	93	111	52	61
	130	89	115	132		9	51	30	27	68	79	7	34
	70	44	46		10+	139	29	29	19	24	7	0	16
	0	23		TOTAL	5333	7425	8699	9286	8185	6785	6056	5517	5076
	4373												

YEAR	2000	2001 2002	2003	2004	2005	2006	2007	2008	2009	2010	GMST	70-**	
AGE													
1	460	476	646	912	1010	961	855	996	592	17	0	1281	1573
2	482	377	394	535	753	834	794	697	811	486	14	1079	1324
3	588	299	286	297	434	616	665	610	526	624	376	896	1110
4	641	398	209	181	231	342	437	488	409	385	447	694	872
5	607	410	209	130	136	171	208	276	223	225	240	519	676
6	228	405	118	123	86	87	89	110	142	113	136	342	455
7	247	117	45	62	71	43	47	36	46	69	65	203	282
8	125	26	4	13	18	39	15	6	13	13	21	97	156
9	86	3	1	1	5	5	19	6	3	2	5	50	99
10+	26		10	1	1	0	2	0	1	1	0	1	
TOTAL3491	2521	1914	2254	2744	3100	3129	3225	2767	1935	1305			

Spawning stock number at age (spawning time) Numbers10^3*

	YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979		
AGE													
	1	0	0	0	0	0	0	0	0	0	0		2
	0	0	0	0	0	0	0	0	0	0		3	909
	713	489	618	617	974	1171	1028	863	889		4	847	926
	887	586	779	781	1237	1473	1289	1054		5	1020	795	790
	833	610	801	814	1335	1548	1214		6	558	608	504	474
	559	461	593	612	1060	1087		7	279	282	336	208	243
	386	309	400	413	682		8	102	136	144	171	83	150
	285	213	277	260		9	67	50	82	73	100	51	110
	214	153	189		10+	72	45	92	105	179	70	298	556
	255	391											

	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989		
AGE													
	1	0	0	0	0	0	0	0	0	0	0		2
	0	0	0	0	0	0	0	0	0	0		3	588
	527	249	244	184	140	155	212	268	194		4	1085	725
	626	246	248	217	179	195	272	329		5	1058	1160	687
	442	210	253	239	194	203	275		6	793	775	874	381
	203	156	214	174	143	127		7	689	477	474	535	180
	124	116	165	106	84		8	441	457	278	275	323	110
	95	81	103	67		9	171	315	296	154	166	229	85
	73	55	59		10+	348	512	653	325	437	508	1015	357
	353	196											

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999

	AGE												
	1	0	0	0	0	0	0	0	0	0	0		2
	0	0	0	0	0	0	0	0	0	0		3	212
	372	634	913	640	545	466	254	448	349		4	197	218
	433	750	983	618	638	569	299	530		5	301	148	203
	441	672	736	488	643	582	285		6	194	198	98	155
	323	352	338	331	440	368		7	62	125	136	67	91
	190	144	164	196	207		8	44	36	83	98	20	48
	100	66	76	112		9	41	25	25	58	55	5	26
	59	36	36		10+	112	25	27	16	17	5	0	14
	0	18											

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
AGE													
	1	0	0	0	0	0	0	0	0	0	0		2
	0	0	0	0	0	0	0	0	0	0		3	228
	118	107	124	182	245	269	236	212	249		4	377	212
	121	115	146	196	255	242	223	223		5	494	219	160
	105	109	123	151	197	158	174		6	172	142	90	98
	64	67	59	75	104	90		7	83	23	25	35	55
	26	18	23	26	40		8	21	6	2	8	10	29
	10	5	6	8		9	43	1	1	1	4	4	12
	4	2	2		10+	13	4	1	1	0	1	0	0
	1	0											

Stock biomass at age (start of year) Tonnes

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979			
AGE													
	1	1060	1318	1296	2044	2493	2198	1854	1950	1271	1153		
2	2285	1546	1923	1891	2981	3636	3206	2704	2844	1854		3	3789
	2774	1940	2414	2371	3744	4570	3989	3367	3542		4	3108	3698
	3106	2089	2685	2719	4290	5087	4488	3750		5	4281	2946	2960
	3236	2101	2885	2870	4557	5449	4734		6	2832	2745	2423	2383
	2419	1999	2513	2606	4415	4969		7	1921	1662	2035	1582	1426
	1952	1608	2116	2173	3848		8	810	848	1001	1164	572	867
	1600	1247	1587	1643		9	537	357	598	570	694	335	721
	1404	1005	1337		10+	734	415	855	1038	1579	583	2471	4634
	2122	3520											
	TOTALBIO	21356	18310	18139	18410	19321	20917	25703	30295	28720	30351		

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989			
	AGE												
	1	603	597	416	293	324	445	560	422	489	725		2
	1682	879	871	606	427	472	648	817	615	658		3	2325
	2095	1076	1095	762	537	593	815	1027	657		4	3778	2522
	2245	980	925	749	616	683	935	928		5	3782	3984	2663
	2230	787	848	805	667	714	742		6	3518	3343	3817	2001
	990	631	853	805	636	579		7	3596	2705	2713	3026	1099
	629	581	812	572	436		8	2534	2768	1759	1735	1981	620
	516	487	704	422		9	1138	2123	2083	1213	1208	1457	536
	483	373	471		10+	2939	4382	5844	3240	4030	4113	8098	3002
	3043	2855											
	TOTALBIO	25895	25398	23488	16420	12532	10501	13806	8993	9106	8474		

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
AGE													
	1	1051	1355	2196	1032	1026	89	993	765	528	358		2
	872	1464	2723	2217	1293	1018	865	1373	1115	771		3	665
	1080	2132	2573	1772	1235	1108	626	1363	1107		4	637	647
	1328	1865	2551	1746	1647	1408	785	1460		5	841	424	618
	1091	1797	2488	1340	1541	1504	789		6	730	712	432	525
	973	1579	1365	1051	1759	1548		7	326	648	801	352	517
	1118	917	919	1141	1335		8	320	230	584	649	307	368
	782	533	689	791		9	329	195	239	565	654	61	320
	660	311	319		10+	1701	363	279	179	226	68	0	173
	0	215											
	TOTALBIO	7473	7118	11331	11048	11118	9769	9338	9048	9195	8692		

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
	AGE												
	1	83	292	397	560	491	154	531	290	126	0		2
	522	408	335	424	733	703	793	554	463	321		3	722
	389	367	383	620	814	1003	853	713	721		4	1005	676
	405	357	452	663	923	922	733	673		5	1350	944	530
	313	343	434	558	675	540	546		6	654	1255	376	384
	273	300	312	342	426	386		7	967	481	186	254	300
	188	211	167	186	291		8	656	145	21	68	106	227
	87	38	63	68		9	570	31	8	8	32	35	140
	45	18	15		10+	214	121	15	7	0	15	0	6
	8	0											
	TOTALBIO	6743	4743	2641	2758	3350	3533	4558	3893	3276	3021		

Spawning stock biomass at age (spawning time) Tonnes

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979			
AGE													
	1	0	0	0	0	0	0	0	0	0	0		2
	0	0	0	0	0	0	0	0	0	0		3	1497
	1174	805	1018	1015	1603	1928	1692	1421	1463		4	1940	2121
	2033	1343	1784	1791	2835	3376	2955	2415		5	3064	2388	2374
	2501	1832	2407	2445	4010	4651	3648		6	2082	2268	1879	1769
	2085	1720	2213	2283	3955	4056		7	1243	1256	1498	926	1083
	1720	1378	1784	1839	3040		8	529	701	743	884	430	778
	1474	1101	1433	1345		9	391	291	480	430	586	298	648
	1256	900	1109		10+	535	338	686	783	1332	519	2222	4144
	1902	2919											

TOTSPBIO	11282	10538	10499	9654	10148	10836	15144	19646	19057	19996		

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989		
AGE												
1	0	0	0	0	0	0	0	0	0	0		2
0	0	0	0	0	0	0	0	0	0		3	968
867	411	402	302	230	254	349	441	271		4	2487	1662
1434	563	568	498	411	448	624	592		5	3179	3486	2064
1328	630	760	719	582	611	604		6	2960	2890	3261	1423
757	581	799	651	533	419		7	3072	2124	2112	2384	804
554	518	736	472	336		8	2281	2362	1437	1424	1671	567
491	419	534	353		9	1005	1849	1737	908	977	1343	501
429	323	391		10+	2596	3816	4874	2424	3261	3790	7568	2666
2633	2369											
TOTSPBIO	18548	19056	17330	10856	8970	8324	11261	6280	6172	5335		

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
AGE												
1	0	0	0	0	0	0	0	0	0	0		2
0	0	0	0	0	0	0	0	0	0		3	264
429	905	1005	685	519	466	254	582	453		4	349	373
864	1157	1567	971	1020	911	508	901		5	651	314	536
920	1400	1635	1024	1350	1281	627		6	630	600	383	459
838	1053	947	927	1364	1142		7	243	530	720	299	382
842	621	706	843	889		8	238	194	524	572	120	286
599	395	455	671		9	266	163	218	486	455	46	251
559	252	254		10+	1373	304	254	154	157	51	0	146
0	171											
TOTSPBIO	4013	2908	4404	5052	5604	5403	4929	5248	5286	5108		

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
AGE												
1	0	0	0	0	0	0	0	0	0	0		2
0	0	0	0	0	0	0	0	0	0		3	280
153	138	160	260	323	405	330	288	288		4	590	360
235	227	285	380	539	458	399	390		5	1098	503	405
253	273	313	404	481	383	423		6	492	439	287	305
203	231	206	233	312	306		7	326	92	103	144	235
116	81	108	104	169		8	111	34	12	44	56	165
58	28	28	44		9	286	12	6	6	26	28	92
33	11	11		10+	107	45	11	6	0	12	0	4
5	0											
TOTSPBIO	3291	1638	1197	1146	1338	1568	1786	1676	1531	1630		

Stock biomass at age with SOP (start of year) Tonnes

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979		
AGE												
1	1060	1318	1296	2044	2493	2198	1855	1950	1271	1153		2
2285	1546	1922	1891	2981	3637	3207	2705	2844	1854		3	3788
2775	1940	2414	2371	3744	4572	3989	3367	3542		4	3108	3699
3106	2089	2684	2719	4291	5088	4488	3750		5	4281	2946	2960
3237	2100	2885	2871	4557	5449	4734		6	2832	2745	2423	2383
2418	2000	2514	2607	4416	4969		7	1921	1663	2035	1582	1426
1952	1608	2117	2173	3848		8	810	849	1001	1164	572	867
1600	1247	1587	1643		9	537	358	598	570	694	335	721
1405	1005	1337		10+	734	415	855	1038	1578	583	2472	4635
2122	3520											
TOTALBIO	21354	18312	18137	18412	19316	20919	25711	30299	28724	30350		

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989		
AGE												
1	603	597	416	293	324	445	560	421	489	725		2
1682	879	871	606	427	472	648	817	615	658		3	2326
2095	1076	1095	762	537	593	814	1027	657		4	3778	2523
2245	980	925	749	616	682	936	928		5	3782	3985	2663
2230	787	848	804	667	714	742		6	3518	3344	3817	2002
990	631	852	805	636	579		7	3596	2705	2713	3027	1099
629	581	812	572	436		8	2534	2769	1759	1735	1981	620
515	487	704	423		9	1138	2123	2083	1213	1208	1458	535
483	374	471		10+	2939	4383	5844	3240	4030	4114	8091	3001
3044	2855											
TOTALBIO	25897	25402	23486	16421	12533	10503	13793	8989	9110	8475		

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
AGE												
1	1038	1330	2196	1032	1026	89	1005	765	528	358		2
861	1437	2723	2217	1293	1018	876	1373	1115	771		3	657
1061	2131	2573	1772	1235	1122	626	1363	1107		4	629	635
1328	1865	2552	1746	1667	1408	785	1460		5	830	416	617
1091	1797	2488	1357	1541	1504	789		6	721	699	432	525
973	1579	1382	1051	1759	1548		7	321	636	800	352	517
1118	928	919	1140	1335		8	316	226	584	649	307	368
792	533	689	791		9	325	191	239	565	655	61	324
660	311	319		10+	1680	356	279	179	226	68	0	173
0	215											
TOTALBIO	7379	6989	11330	11049	11119	9769	9454	9048	9195	8692		

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
AGE												
1	85	293	397	561	506	154	532	279	121	0		2
536	410	335	424	755	702	795	533	444	320		3	741
390	367	384	639	813	1005	822	684	720		4	1032	678
405	357	466	662	925	888	703	672		5	1386	947	530
314	354	434	560	650	518	546		6	672	1259	376	385
282	300	313	330	408	386		7	993	483	186	255	309
188	211	161	179	291		8	673	146	21	68	109	227
87	37	60	68		9	586	31	8	8	33	35	140
44	17	15		10+	219	122	15	7	0	15	0	6
8	0											
TOTALBIO	6924	4758	2641	2762	3454	3529	4567	3749	3143	3020		

Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979		
AGE												
1	0	0	0	0	0	0	0	0	0	0		2
0	0	0	0	0	0	0	0	0	0		3	1497
1174	805	1018	1015	1603	1929	1692	1421	1463		4	1940	2122

	2033	1343	1784	1791	2836	3376	2956	2415		5	3064	2389	2374
	2501	1832	2407	2446	4010	4652	3648		6	2082	2268	1878	1769
	2084	1721	2214	2284	3956	4056		7	1243	1256	1498	926	1083
	1720	1379	1784	1840	3040		8	529	701	743	884	430	778
	1475	1101	1433	1345		9	391	291	480	430	585	298	648
	1256	900	1109		10+	535	338	686	783	1332	519	2223	4145
	1902	2919											
TOTSPBIO		11281	10539	10497	9655	10145	10837	15149	19649	19060	19995		
	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989		
AGE													
	1	0	0	0	0	0	0	0	0	0	0		2
	0	0	0	0	0	0	0	0	0	0		3	969
	867	411	402	302	230	254	349	441	271		4	2488	1662
	1434	563	568	498	411	447	624	592		5	3179	3487	2064
	1328	630	760	719	582	611	604		6	2960	2890	3261	1423
	757	581	798	651	534	419		7	3072	2124	2112	2384	804
	554	517	736	473	336		8	2281	2363	1437	1424	1672	567
	491	419	535	353		9	1005	1849	1737	908	977	1343	500
	429	323	391		10+	2596	3817	4873	2425	3261	3791	7561	2665
	2633	2369											
TOTSPBIO		18550	19059	17329	10857	8971	8325	11251	6277	6174	5335		
	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
	AGE												
	1	0	0	0	0	0	0	0	0	0	0		2
	0	0	0	0	0	0	0	0	0	0		3	261
	422	905	1005	685	519	472	254	582	453		4	345	366
	864	1157	1567	971	1033	911	508	901		5	643	308	536
	920	1400	1635	1037	1350	1280	627		6	622	589	383	459
	838	1053	959	927	1364	1142		7	240	521	720	299	382
	842	628	706	843	889		8	235	191	524	572	120	286
	606	395	455	671		9	262	160	218	486	455	46	254
	559	252	254		10+	1356	299	254	154	157	51	0	146
	0	171											
TOTSPBIO		3963	2855	4403	5053	5605	5404	4990	5248	5285	5108		
	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
AGE													
	1	0	0	0	0	0	0	0	0	0	0		2
	0	0	0	0	0	0	0	0	0	0		3	288
	154	138	160	268	323	406	318	276	288		4	606	361
	235	228	294	379	540	441	383	390		5	1127	505	405
	254	282	312	405	464	368	423		6	506	440	287	306
	209	231	207	225	300	306		7	335	93	102	145	242
	116	81	104	100	169		8	114	34	12	44	58	165
	58	27	27	44		9	294	12	6	6	27	28	93
	32	11	11		10+	110	45	11	6	0	12	0	4
	5	0											
TOTSPBIO		3379	1643	1196	1147	1379	1566	1790	1614	1469	1630		

Summary (without SOP correction)

Age	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3-7
1970	1726	21356	11282	5273	0.4674	0.4134
1971	2147	18310	10538	3052	0.2896	0.2611
1972	2111	18139	10499	3049	0.2904	0.2565
1973	3329	18410	9654	3705	0.3838	0.381
1974	4060	19321	10148	1696	0.1671	0.1495
1975	3579	20917	10836	1273	0.1175	0.1117
1976	3020	25703	15144	1584	0.1046	0.1099
1977	3175	30295	19646	2012	0.1024	0.1019
1978	2070	28720	19057	2160	0.1133	0.1085
1979	1878	30351	19996	5447	0.2724	0.2319
1980	981	25895	18548	2843	0.1533	0.1416
1981	973	25398	19056	3276	0.1719	0.1506
1982	677	23488	17330	4662	0.269	0.252
1983	477	16420	10856	5307	0.4889	0.4836
1984	527	12532	8970	2852	0.3179	0.3091
1985	724	10501	8324	527	0.0633	0.052
1986	912	13806	11261	428	0.038	0.0399
1987	687	8993	6280	849	0.1352	0.1092
1988	796	9106	6172	1116	0.1808	0.1312
1989	1449	8474	5335	1452	0.2722	0.2732
1990	2300	7473	4013	1392	0.3469	0.3114
1991	3538	7118	2908	935	0.3215	0.2807
1992	3021	11331	4404	438	0.0995	0.0834
1993	2279	11048	5052	1601	0.3169	0.1765
1994	1710	11118	5604	2139	0.3817	0.2778
1995	987	9769	5403	2924	0.5411	0.4471
1996	1617	9338	4929	2031	0.412	0.3702
1997	1245	9048	5248	1014	0.1932	0.1665
1998	861	9195	5286	1574	0.2978	0.2238
1999	583	8692	5108	1933	0.3784	0.3487
2000	460	6743	3291	2776	0.8436	0.6458
2001	476	4743	1638	2522	1.5395	1.378
2002	646	2641	1197	592	0.4947	0.4858
2003	912	2758	1146	408	0.3561	0.3559
2004	1010	3350	1338	425	0.3177	0.2642
2005	961	3533	1568	726	0.4629	0.4424
2006	855	4558	1786	959	0.537	0.6781
2007	996	3893	1676	1030	0.6145	0.5465
2008	592	3276	1531	811	0.5298	0.5223
2009	17	3021	1630	706	0.433	0.4217

Summary (with SOP correction)

Age	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 3-7
1970	1726	21354	11281	5273	0.4674	0.9999	0.4134
1971	2147	18312	10539	3052	0.2896	1.0001	0.2611
1972	2111	18137	10497	3049	0.2905	0.9999	0.2565
1973	3329	18412	9655	3705	0.3837	1.0001	0.381
1974	4060	19316	10145	1696	0.1672	0.9998	0.1495
1975	3579	20919	10837	1273	0.1175	1.0001	0.1117
1976	3020	25711	15149	1584	0.1046	1.0003	0.1099
1977	3175	30299	19649	2012	0.1024	1.0002	0.1019
1978	2070	28724	19060	2160	0.1133	1.0001	0.1085
1979	1878	30350	19995	5447	0.2724	1	0.2319
1980	981	25897	18550	2843	0.1533	1.0001	0.1416
1981	973	25402	19059	3276	0.1719	1.0002	0.1506
1982	677	23486	17329	4662	0.269	0.9999	0.252
1983	477	16421	10857	5307	0.4888	1.0001	0.4836
1984	527	12533	8971	2852	0.3179	1.0001	0.3091
1985	724	10503	8325	527	0.0633	1.0002	0.052
1986	912	13793	11251	428	0.038	0.9991	0.0399
1987	687	8989	6277	849	0.1352	0.9995	0.1092
1988	796	9110	6174	1116	0.1808	1.0004	0.1312
1989	1449	8475	5335	1452	0.2721	1.0001	0.2732
1990	2300	7379	3963	1392	0.3513	0.9875	0.3114
1991	3538	6989	2855	935	0.3275	0.982	0.2807
1992	3021	11330	4403	438	0.0995	0.9999	0.0834
1993	2279	11049	5053	1601	0.3169	1.0002	0.1765
1994	1710	11119	5605	2139	0.3816	1.0001	0.2778
1995	987	9769	5404	2924	0.5411	1	0.4471
1996	1617	9454	4990	2031	0.407	1.0124	0.3702
1997	1245	9048	5248	1014	0.1932	1	0.1665
1998	861	9195	5285	1574	0.2978	0.9999	0.2238
1999	583	8692	5108	1933	0.3784	1	0.3487
2000	460	6924	3379	2776	0.8215	1.0268	0.6458
2001	476	4758	1643	2522	1.5348	1.0031	1.378
2002	646	2641	1196	592	0.4949	0.9997	0.4858
2003	912	2762	1147	408	0.3556	1.0015	0.3559
2004	1010	3454	1379	425	0.3081	1.031	0.2642
2005	961	3529	1566	726	0.4635	0.9987	0.4424
2006	855	4567	1790	959	0.5358	1.0021	0.6781
2007	996	3749	1614	1030	0.638	0.9631	0.5465
2008	592	3143	1469	811	0.5522	0.9595	0.5223
2009	17	3020	1630	706	0.4332	0.9996	0.4217

Lowestoft	*VPA Analysis*	*Version*	*3.1*									*Extended*	*Survivors*
	BLACK	*SEA*	*TURBOT*	*1970 - 2009*									
	Catch	data	for	40	years.	1970	to	2009	Ages	1	to	10	
	Fleet	First	Last	First	Last	Alpha	Beta						year
	year	age	age									RO	Trawl
	fleet	2003	2009	2	7	0.25	0.8				UKR	Trawl	survey
	1989	2009	2	9	0.25	0.8				BG	Trawl	fleet	2006
	2009	2	9	0.25	0.8				TR	CPUE	1987	2009	2
	9	0.25	0.8										
	Time	series	weights	:									
	Tapered	time	weighting	not	applied								
	Catchability		analysis	:									
	Catchability		dependent	on	stock	size	for	ages	<	3			
	Regression	type	=	C									
	Minimum	of	5	points	used	for	regression						
	Survivor	estimates	shrunk	to	the	population	mean	for	ages	<	3		
	Catchability		independent	of	age	for	ages	>=	5				

Terminal population estimation :
Survivor estimates shrunk towards the mean F

of the final 5 years or the 5 oldest ages.
S.E. of the mean to which the estimates are shrunk = 0.5

Minimum standard error for population

estimates derived from each fleet = 0.3
Prior weighting not applied
Tuning converged after 29 iterations
Regression weights

1 1 1 1 1 1 1 1 1 1

Fishing mortalities

	Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
1	0.009	0	0	0.002	0.001	0.002	0.014	0.016	0.008	0.001		2	0.288
	0.085	0.093	0.018	0.011	0.036	0.074	0.092	0.072	0.067		3	0.202	0.167
	0.27	0.059	0.048	0.154	0.121	0.209	0.123	0.144		4	0.256	0.451	0.282
	0.092	0.114	0.306	0.267	0.592	0.406	0.28		5	0.216	1.06	0.341	0.228
	0.256	0.459	0.451	0.477	0.489	0.315		6	0.474	2.005	0.444	0.364	0.505
	0.424	0.73	0.672	0.525	0.372		7	2.08	3.207	1.092	1.037	0.398	0.869
	1.821	0.783	1.067	0.998		8	3.449	2.833	0.997	0.774	1.166	0.544	0.709
	0.512	1.528	0.787		9	1.286	1.905	0.569	0.379	0.351	0.363	0.732	0.523
	0.816	0.559											

XSA *population numbers (Thousands)*
AGE

	YEAR	1	2	3	4	5	6	7	8	9			
	2000	4.60E+02	4.82E+02	5.88E+02	6.41E+02	6.07E+02	2.28E+02	2.47E+02	1.25E+02	8.62E+01			2001
	4.76E+02	3.77E+02	2.99E+02	3.98E+02	4.10E+02	4.05E+02	1.17E+02	2.55E+01	3.29E+00			2002	6.46E+02
	3.94E+02	2.86E+02	2.09E+02	2.09E+02	1.18E+02	4.51E+01	3.93E+00	1.24E+00			2003	9.12E+02	5.35E+02
	2.97E+02	1.81E+02	1.30E+02	1.23E+02	6.24E+01	1.25E+01	1.20E+00			2004	1.01E+03	7.53E+02	4.34E+02
	2.31E+02	1.36E+02	8.59E+01	7.08E+01	1.83E+01	4.77E+00			2005	9.61E+02	8.34E+02	6.16E+02	3.42E+02
	1.71E+02	8.73E+01	4.29E+01	3.93E+01	4.71E+00			2006	8.55E+02	7.94E+02	6.65E+02	4.37E+02	2.08E+02
	8.91E+01	4.72E+01	1.49E+01	1.89E+01			2007	9.96E+02	6.97E+02	6.10E+02	4.88E+02	2.76E+02	1.10E+02
	3.55E+01	6.32E+00	6.05E+00			2008	5.92E+02	8.11E+02	5.26E+02	4.09E+02	2.23E+02	1.42E+02	4.63E+01
	1.34E+01	3.13E+00			2009	1.68E+01	4.86E+02	6.24E+02	3.85E+02	2.25E+02	1.13E+02	6.94E+01	1.32E+01
	2.41E+00												

Estimated population abundance at 1st Jan 2010
0.00E+00 1.39E+01 3.76E+02 4.47E+02 2.40E+02 1.36E+02 6.45E+01 2.12E+01 4.96E+00
Taper weighted geometric mean of the VPA populations:

1.13E+03 1.05E+03 8.76E+02 6.75E+02 4.98E+02 3.25E+02 1.90E+02 8.79E+01 4.30E+01
Standard error of the weighted Log(VPA populations) :

0.9384 0.652 0.6698 0.702 0.7729 0.8183 0.9004 1.218 1.592
Log catchability residuals.

Fleet: RO Trawl fleet

	Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
	2	99.99	99.99	99.99	0.39	0.08	-0.45	-0.6	-0.45	1.22	-0.19		3
	99.99	99.99	99.99	0.32	-0.12	-0.35	-0.47	-0.1	0.85	-0.14		4	99.99
	99.99	99.99	-0.09	-0.54	-0.21	-0.22	0.34	0.82	-0.11		5	99.99	99.99
	99.99	-0.03	0.11	-0.04	0.33	-0.25	0.17	-0.29		6	99.99	99.99	99.99
	0.35	0.75	-0.36	0.13	-0.37	-0.4	-0.17		7	99.99	99.99	99.99	0.97
	-0.38	0.35	0.22	0.37	0.08	0.14		8	No	data	for	this	fleet
	at	this	age				9	No	data	for	this	fleet	at
	this	age											
	Mean	log	catchability		and	standard	error	of	ages	with	catchability		
	independent	of	year	class	strength	and	constant	w.r.t.	time				

Age	3	4	5	6	7
Mean Logq	-1.5009	-0.6392	-0.1541	-0.1541	-0.1541
S.E(Log q)	0.4503	0.4459	0.2206	0.4401	0.4863

Regression statistics :
Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Log	q
2	0.76	0.181	3.74	0.1	7	0.7	-2.86				

Ages with q independent of year class strength and constant w.r.t. time.

	Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Q		
3	3.75	-1.184	-11.57	0.04	7	1.63	-1.5					4	0.63
	1.242	2.57	0.69	7	0.27	-0.64					5	1.28	-0.651
	-1.29	0.51	7	0.3	-0.15					6	8.59	-0.943	-33.94
	0	7	3.82	-0.17					7	1.49	-0.492	-2.09	0.17
	7	0.65	0.1										

Fleet: UKR Trawl survey

Age	1987	1988	1989										
	2	99.99	99.99	0.44									3
	99.99	99.99	0.36									4	99.99
	99.99	-0.67									5	99.99	99.99
	-0.61									6	99.99	99.99	0.36
								7	99.99	99.99	0.1		
						8	99.99	99.99	-0.4				
				9	99.99	99.99	-0.34						

	Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
2	-1.23	0.32	0.93	0.05	0.29	99.99	99.99	99.99	99.99	99.99		3	-1.08
	-0.07	0.06	-0.86	-0.55	99.99	99.99	99.99	-1.6	99.99		4	-0.79	0.25
	-0.52	-1.32	-1.63	99.99	99.99	99.99	-0.82	99.99		5	-1.65	-0.17	-0.38
	-0.68	-1.14	99.99	99.99	99.99	-0.92	99.99		6	-0.89	-0.44	0.54	-0.01
	-0.78	99.99	99.99	99.99	0.21	99.99		7	0.34	-0.27	-0.1	0.78	0.44
	99.99	99.99	99.99	0.46	99.99		8	0.17	-0.54	-1.08	0.28	1.8	99.99
	99.99	99.99	0.77	99.99		9	-0.06	-0.3	-0.04	0.64	0.66	99.99	99.99
	99.99	0.3	99.99										
	Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		

2	99.99	1.47	99.99	0.43	-0.66	0.08	-1.68	-0.45	99.99	99.99		3	99.99
	1.32	1.27	0.27	0.35	-0.61	0.46	0.68	99.99	99.99		4	99.99	0.68
	1.04	0.33	0.76	-0.31	1.55	1.47	99.99	99.99		5	99.99	0.4	0.86
	0.88	0.84	0.44	1.17	0.95	99.99	99.99		6	99.99	-0.35	1.16	1.47
	1.82	1.17	1.68	1.21	99.99	99.99		7	99.99	-0.17	2.25	2.86	2.12
	2.77	2.5	2.04	99.99	99.99		8	99.99	-0.76	2.58	2.9	2.92	2.39
	1.25	2.15	99.99	99.99		9	99.99	0.86	1.99	2.17	2.7	2.78	1.29
	2.49	99.99	99.99										

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

	Age	3	4	5	6	7	8	9
Mean Log	q	-3.3828	-2.2194	-1.4296	-1.4296	-1.4296	-1.4296	-1.4296
S.E(Log	q)	0.8555	1.0143	0.9065	1.0629	1.6885	1.7903	1.6027

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Log	q
	2	1.2	-0.46	4.44	0.34	12	0.93	-4.85			
	Ages	with	q	independent of		year	class	strength	and	constant	w.r.t.	time.

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Q		
3	5.33	-2.826	-10.18	0.03	14	3.68	-3.38					4
-16.36	-2.851	69.41	0	14	13.34	-2.22					5	-7.25
-3.698	36.4	0.02	14	4.68	-1.43					6	-5.77	-4.417
29.45	0.03	14	3.41	-0.92					7	-1.49	-4.828	10.64
0.24	14	1.08	-0.28					8	7.45	-2.906	-19.33	0.02
14	8.52	-0.4					9	2.42	-4.149	-2.87	0.42	14
1.85	-0.35											

Fleet: BG Trawl fleet

	Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
	2	99.99	99.99	99.99	99.99	99.99	99.99	0.44	0.28	0.46	-1.18		3
	99.99	99.99	99.99	99.99	99.99	99.99	0.04	0.35	-0.19	-0.2		4	99.99
	99.99	99.99	99.99	99.99	99.99	-0.81	0.64	0.32	-0.15		5	99.99	99.99
	99.99	99.99	99.99	99.99	-1.3	0.31	0.83	0.17		6	99.99	99.99	99.99
	99.99	99.99	99.99	-0.82	0.48	0.78	0.48		7	99.99	99.99	99.99	99.99
	99.99	99.99	-0.5	-0.18	0.08	0.07		8	99.99	99.99	99.99	99.99	99.99
	99.99	-0.3	-0.2	0.16	0.02		9	99.99	99.99	99.99	99.99	99.99	99.99
	-1.62	99.99	0.57	0.22									

Mean log catchability and standard error of ages with catchability independent of
year class strength and constant w.r.t. time

	Age	3	4	5	6	7	8	9
Mean Log	q	-1.4346	-0.9563	-0.5926	-0.5926	-0.5926	-0.5926	-0.5926
S.E(Log	q)	0.2613	0.6278	0.9153	0.7632	0.3151	0.2264	1.2265

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Log	q
2	0.23	7.609	5.52	0.98	4	0.04	-2.19				

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Q		
3	0.52	0.532	3.82	0.38	4	0.16	-1.43					4
0.31	0.542	4.47	0.24	4	0.22	-0.96					5	0.22
0.753	4.38	0.32	4	0.22	-0.59					6	0.23	2.986
3.73	0.88	4	0.09	-0.37					7	0.72	0.594	1.6
0.69	4	0.22	-0.73					8	0.88	0.395	0.89	0.84
4	0.21	-0.67					9	-76.35	-3.642	61.25	0	3
33.67	-0.87											

Fleet: TR CPUE

	Age	1987	1988	1989									
2	-0.86	-0.52	0.98									3	-3.33
	-3.35	1.77									4	-1.66	-4.79
	0.86									5	-0.3	-3.7	0.67
								6	0.28	1.16	1.86		
						7	1.66	1.88	2.41				
				8	1.14	1.72	1.97						
		9	1.23	2.79	1.36								

	Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
2	0.67	0.61	-0.29	0.21	-0.55	0.55	1.14	-1.76	-1.44	-1.23		3	2.59
	2.67	1.07	1.77	2.48	2.06	0.32	-7.2	-7.38	-7.71		4	1.45	2.32
	-0.35	0.37	1.47	0.16	-1.35	-0.71	-1.59	-0.68		5	0.86	1.8	-0.16
	-0.57	1.03	1.29	-0.5	-1.67	-1.79	-0.16		6	1.25	1.19	0.07	-0.34
	1.72	2.53	0.18	-1.06	-0.41	-0.76		7	1.46	1.4	-0.5	-0.4	1.81
	2.46	1.25	-0.21	1.28	0.7		8	1.57	2.4	0.11	-1.35	2.95	2.8
	0.84	1.01	1.63	1.08		9	1.29	1.3	0.9	-0.82	1.85	3.43	1.34
	0.37	1.8	0.45										

	Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
2	0.99	-0.67	-0.67	0.69	0.6	0.18	0.79	0.94	0.43	-0.79		3	2.63
	1	1.36	1.1	0.76	1.17	1.79	1.82	1.61	1		4	0.6	-0.6
	0.48	0.31	0.25	1.07	0.72	1	0.05	0.62		5	0.04	-0.08	-0.67
	-0.26	0.03	0.98	0.95	1.26	0.62	0.33		6	0.94	1.01	0.13	0.38
	0.79	1.27	1.63	1.55	0.38	0.34		7	1.33	3.06	1.05	1.75	1.12
	1.47	2.3	2.06	1.45	0.34		8	3.55	3.29	3.1	3.29	2.48	1.2
	2.76	2.64	1.23	1.55		9	2.35	3.36	1.55	3.65	2.8	2.82	0.88
	0.65	1.19	-4.16										

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

	Age	3	4	5	6	7	8	9
Mean Log	q	-2.8567	-0.9968	-0.1023	-0.1023	-0.1023	-0.1023	-0.1023
S.E(Log	q)	3.3215	1.4441	1.2058	1.1454	1.6534	2.2395	2.1828

Regression statistics :

Ages with q dependent on year class strength

	Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Log	q	
	2	0.28	2.12	6.4	0.29	23	0.89	-5.42					
	Ages	with	q	independent of		year	class	strength	and	constant	w.r.t.	time.	
	Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Q		
	3	1.21	-0.134	2.07	0.02	23	4.13	-2.86					4
	1.02	-0.04	0.88	0.13	23	1.51	-1					5	1.17
	-0.337	-0.86	0.16	23	1.44	-0.1					6	1.31	-0.769
	-2.4	0.23	23	1.18	0.6					7	1.22	-0.613	-2.54
	0.27	23	1.12	1.25					8	2.08	-2.463	-7.7	0.2
	23	2.19	1.77					9	1.11	-0.412	-1.76	0.4	23
	1.86	1.31											

Terminal year survivor and F summaries :

	Age	1	Catchability		dependent	on	age	and	year	class	strength		
Year	class	=	2008										
	Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
Survivors	s.e	s.e	Ratio	Weights	F								
RO	Trawl	fleet	1	0	0	0	0	0	0			UKR	Trawl
	survey	1	0	0	0	0	0	0			BG	Trawl	fleet
	1	0	0	0	0	0	0			TR	CPUE	1	0
	0	0	0	0	0								
	P	shrinkage	mean	1050	0.65	0.37	0						F
	shrinkage	mean	1	0.5	0.63	0.008							
	Weighted	prediction	:										
	Survivors	Int	Ext	N	Var	F							
	at	end	of	year	s.e	s.e	Ratio						
	14	0.4	4.23	2	10.671	0.001							

	Age	2	Catchability		dependent	on	age	and	year	class	strength		
	Year	class	=	2007									
	Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
Survivors	s.e	s.e	Ratio	Weights	F								
RO	Trawl	fleet	310	0.781	0	0	1	0.153	0.08				
UKR	Trawl	survey	1	0	0	0	0	0	0			BG	Trawl
	fleet	115	0.887	0	0	1	0.119	0.203			TR	CPUE	171
	0.941	0	0	1	0.105	0.141							
	P	shrinkage	mean	876	0.67	0.223	0.029						F
	shrinkage	mean	442	0.5	0.4	0.057							
	Weighted	prediction	:										
	Survivors	Int	Ext	N	Var	F							
	at	end	of	year	s.e	s.e	Ratio						
	376	0.31	0.46	5	1.483	0.067							

	Age	3	Catchability		constant	w.r.t.	time	and	dependent	on	age		
	Year	class	=	2006									
Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated						
	Survivors	s.e	s.e	Ratio	Weights								
RO	Trawl	fleet	505	0.429	0.537	1.25	2	0.228	0.129			UKR	Trawl
	survey	1	0	0	0	0	0	0			BG	Trawl	fleet
	389	0.284	0.196	0.69	2	0.524	0.164			TR	CPUE	714	0.878
	0.148	0.17	2	0.052	0.093								
									F	shrinkage	mean	493	0.5
	0.197	0.131											
	Weighted	prediction	:										
	Survivors	Int	Ext	N	Var	F							
	at	end	of	year	s.e	s.e	Ratio						
	447	0.21	0.14	7	0.661	0.144							

	Age	4	Catchability		constant	w.r.t.	time	and	dependent	on	age		
	Year	class	=	2005									
	Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
	Survivors	s.e	s.e	Ratio	Weights	F							
	RO	Trawl	fleet	301	0.311	0.37	1.19	3	0.319	0.229			UKR
	Trawl	survey	154	0.988	0	0	1	0.028	0.409			BG	Trawl
	fleet	207	0.264	0.09	0.34	3	0.428	0.318			TR	CPUE	575
	0.762	0.159	0.21	3	0.05	0.127							
	F	shrinkage	mean	192	0.5	0.176	0.339						
	Weighted	prediction	:										
	Survivors	Int	Ext	N	Var	F							
	at	end	of	year	s.e	s.e	Ratio						
	240	0.18	0.13	11	0.738	0.28							

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2004

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
Survivors	s.e	s.e	Ratio	Weights	F							
RO	Trawl	fleet	125	0.223	0.244	1.09	4	0.501	0.339			UKR
Trawl	survey	109	0.686	1.146	1.67	2	0.032	0.38			BG	Trawl
fleet	190	0.26	0.037	0.14	4	0.26	0.235			TR	CPUE	222
0.677	0.211	0.31	4	0.047	0.204							
F	shrinkage	mean	94	0.5	0.159	0.429						

Weighted	prediction	:				
Survivors	Int	Ext	N	Var	F	
at	end	of	year	s.e	s.e	Ratio
136	0.16	0.12	15	0.78	0.315	

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2003

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
Survivors	s.e	s.e	Ratio	Weights	F							
RO	Trawl	fleet	65	0.213	0.124	0.58	5	0.503	0.371			UKR
Trawl	survey	124	0.555	0.399	0.72	3	0.034	0.21			BG	Trawl
fleet	86	0.288	0.168	0.58	4	0.206	0.291			TR	CPUE	102
0.64	0.146	0.23	5	0.057	0.251							
												F
shrinkage	mean	37	0.5	0.199	0.576							

Weighted	prediction	:				
Survivors	Int	Ext	N	Var	F	
at	end	of	year	s.e	s.e	Ratio
65	0.16	0.1	18	0.64	0.372	

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2002

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
Survivors	s.e	s.e	Ratio	Weights	F							
RO	Trawl	fleet	18	0.208	0.094	0.45	6	0.361	1.105			UKR
Trawl	survey	31	0.489	0.534	1.09	4	0.033	0.783			BG	Trawl
fleet	23	0.303	0.172	0.57	4	0.268	0.944			TR	CPUE	39
0.614	0.147	0.24	6	0.04	0.663							
F	shrinkage	mean	21	0.5	0.297	0.998						

Weighted	prediction	:				
Survivors	Int	Ext	N	Var	F	
at	end	of	year	s.e	s.e	Ratio
21	0.19	0.07	21	0.383	0.998	

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2001

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
Survivors	s.e	s.e	Ratio	Weights	F							
RO	Trawl	fleet	5	0.213	0.117	0.55	6	0.146	0.768			UKR
Trawl	survey	10	0.463	0.275	0.6	5	0.019	0.466			BG	Trawl
fleet	5	0.245	0.076	0.31	4	0.502	0.773			TR	CPUE	18
0.803	0.135	0.17	7	0.023	0.282							
F	shrinkage	mean	4	0.5	0.31	0.901						

Weighted	prediction	:				
Survivors	Int	Ext	N	Var	F	
at	end	of	year	s.e	s.e	Ratio
5	0.2	0.07	23	0.328	0.787	

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2000

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
Survivors	s.e	s.e	Ratio	Weights	F							
RO	Trawl	fleet	1	0.219	0.139	0.63	5	0.092	0.515			UKR
Trawl	survey	3	0.535	0.354	0.66	5	0.013	0.228			BG	Trawl
fleet	1	0.278	0.108	0.39	4	0.303	0.527			TR	CPUE	0
1.25	1.016	0.81	8	0.03	0							
F	shrinkage	mean	1	0.5	0.562	0.555						

Weighted prediction :

Survivors	Int	Ext	N	Var	F	
at	end	of	year	s.e	s.e	Ratio
1	0.3	0.13	23	0.425	0.559	

The XSA estimated recruitment has two peaks in 1974 – 1976 and 1991 – 1992 and to lows in1983-84 and 2000. There is some rise in recruitment after 2001. Correspondingly, SSB attained higher values up to 20,000 t in 1977 – 1981 and very low values after 2000. For the recent period however the WG is aware of severe misreporting of actual catches which could have contributed to the underestimation of stock abundance. Fishing mortality $F_{4\text{-}8}$ has a peak of F~2 in 2000-2001 and keeps as high as F = 0.6 - 0.8 thereafter (Fig. 2.4.1.3.2).

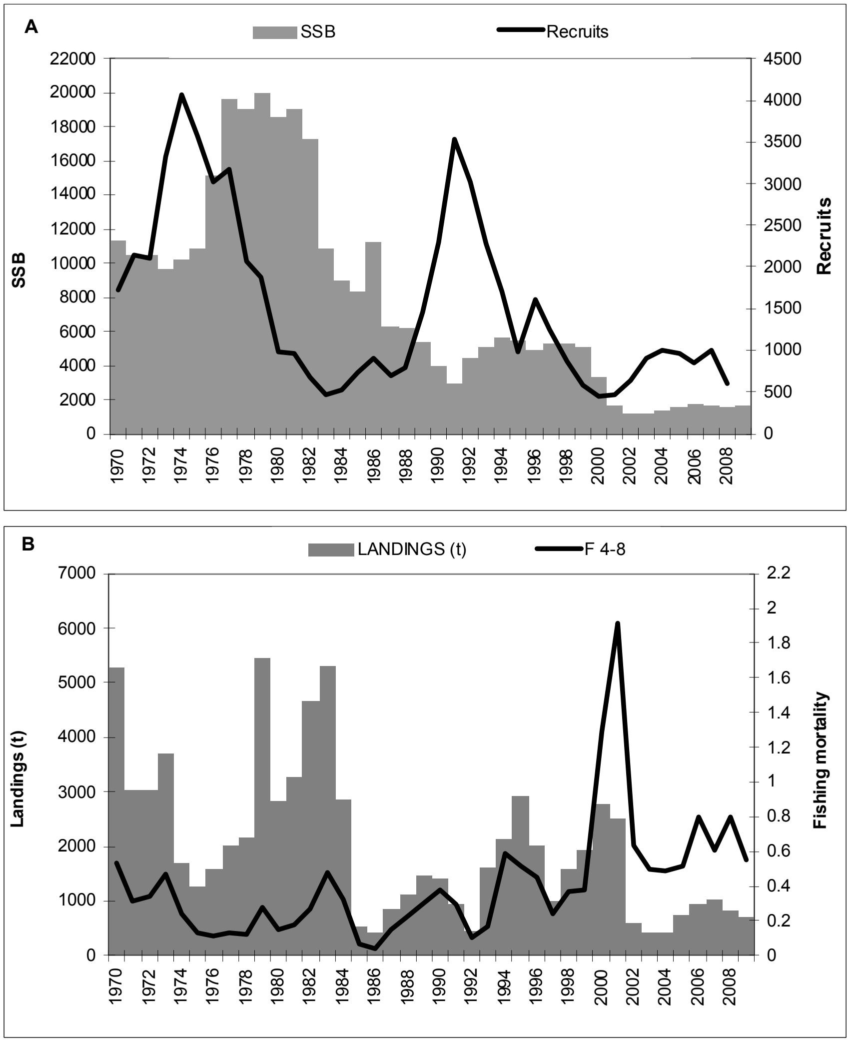


Fig. 4.2.6.3.2. Time-series of turbot population estimates of total stock in the Black Sea (XSA version with terminal F shrinkage): A. recruitment (line) and SSB (grey); B. landings (grey) and average fishing mortality (ages 4–8, line).

The analysis of relative trends of age composition of turbot (Fig. 4.2.6.3.3) manifests, that low levels of official catches reported after 2001 do not result in biomass increase or in larger share of older age groups in the stock. These trends indicate possible effects higher fishing pressure due to illegal fishing.

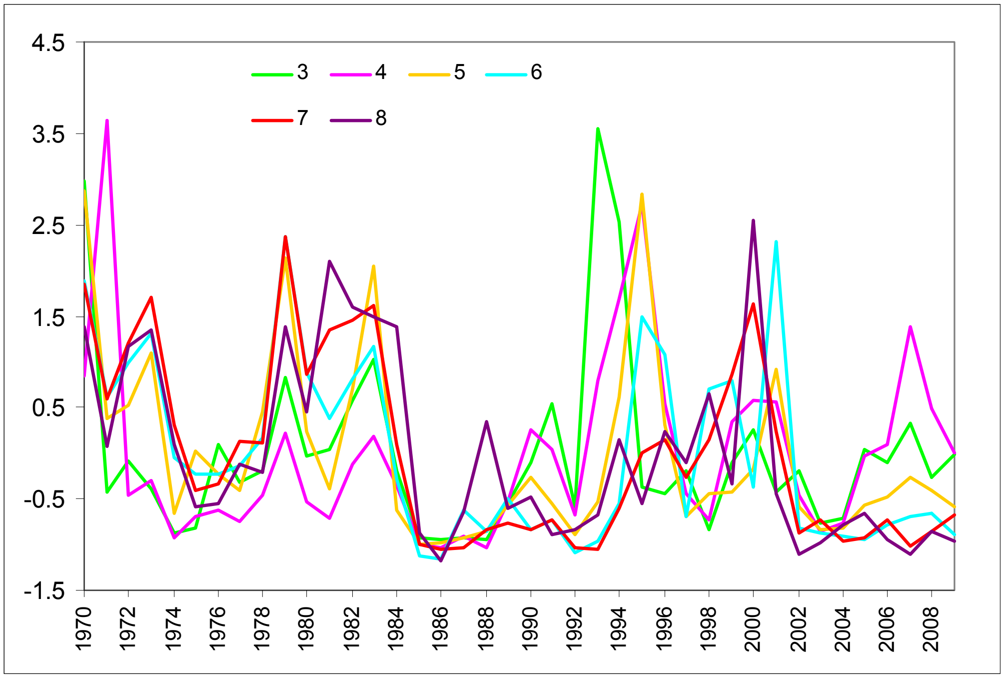


Fig. 4.2.6.3.3. Relative trends (ammomalies with mean 0, SD=1) in turbot age structure diring the period 1970 – 2009.

The STECF SG Black Sea-10-01 made qualitative assumptions about the IUU (Illegal, Unregulated and Unreported) fishing of turbot and estimated the Potential Unreported Catch in 2002-2009.

The estimate of IUU catches of turbot was based on the fact that officially reported landings (mostly by Turkey) dropped suddenly in 2002 (Table 4.2.6.3.1. Fig. 4.2.6.3.2. B). This drop followed some accidents between maritime police and illegal Turkish fishermen in Bulgarian, Romanian, and Ukrainian waters. The WG realised tha the much highest catch by Turkey until 2001 (between 1000 and 2000 t) has been actually taken illegaly from the north-western part of the Black Sea where are the main aggregations of the stock , transported and sold on the Turkish market and finally reported as Turkish catch (that actually it is). After 2001 Turkish turbot fishery had to rely only on the exausted turbot stock along the narrow southern Black Sea shelf (Turkish waters) and Turkish landings dropped to about 100-300 t on average (Table 4.2.6.3.1.) leading to a substantial drop in the total reported landings (Fig. 4.2.6.3.2. B).

On the other hand, the STECF SG Black Sea-10-01 has qualitative information that IUU fishing in Bulgarian, Romanian, and Ukrainian waters is a common practice and that unreported catches may exceed the officially reported by oredrs of magnitude. The WG than made the assumption that what has been caught by illegal Turkish fishermen is the Bulgarian, Romanian, and Ukrainian waters is now caught by the local fishermen and is named Potential Unreported Catch. It was estimated as a proportion between Turkish catch in 1993-2001 and 2009-2010, which then was added to the officially reported catch (Fig. 2.4.1.3.4).

The estimated total catch was about 59% (2.5 times) higher than the reported landings on average for 2002-2009. The STECF SG Black Sea-10-01 considers this value as a maximum potential value and assumes that actual catch may lay in the region between the estimated and reported catch. Based on the estimated catches the historic assessment was run. The differences between the two assessments are during the last decade 2000-2009 when landings are considered as under-reported. The resulted recruitment and SSB were higher by 57% and 67% respectively, and the average fishing mortality (F4-8) lower by 13%.

The STECF SG Black Sea-10-01 suggests that special investigations are performed in future in order to better identify the levels of IUU of turbot for the needs of stock assessment.

Because of uncertainties about actual catch the STECF SG Black Sea-10-01 interprets the assessment only in relative terms – i.e. they are considered indicative of trends only. Biomass of turbot is low compared to historical levels. The drop in abundance is consistent with the decreases in CPUE and landings. Recruitment has increased in 2004-2006 and positively influenced the SSB, but given the high exploitation rate such a positive influence may not propagate in the next years. Fishing mortality of turbot is rather high: F =0.6 – 0.8 (given that M=0.19).

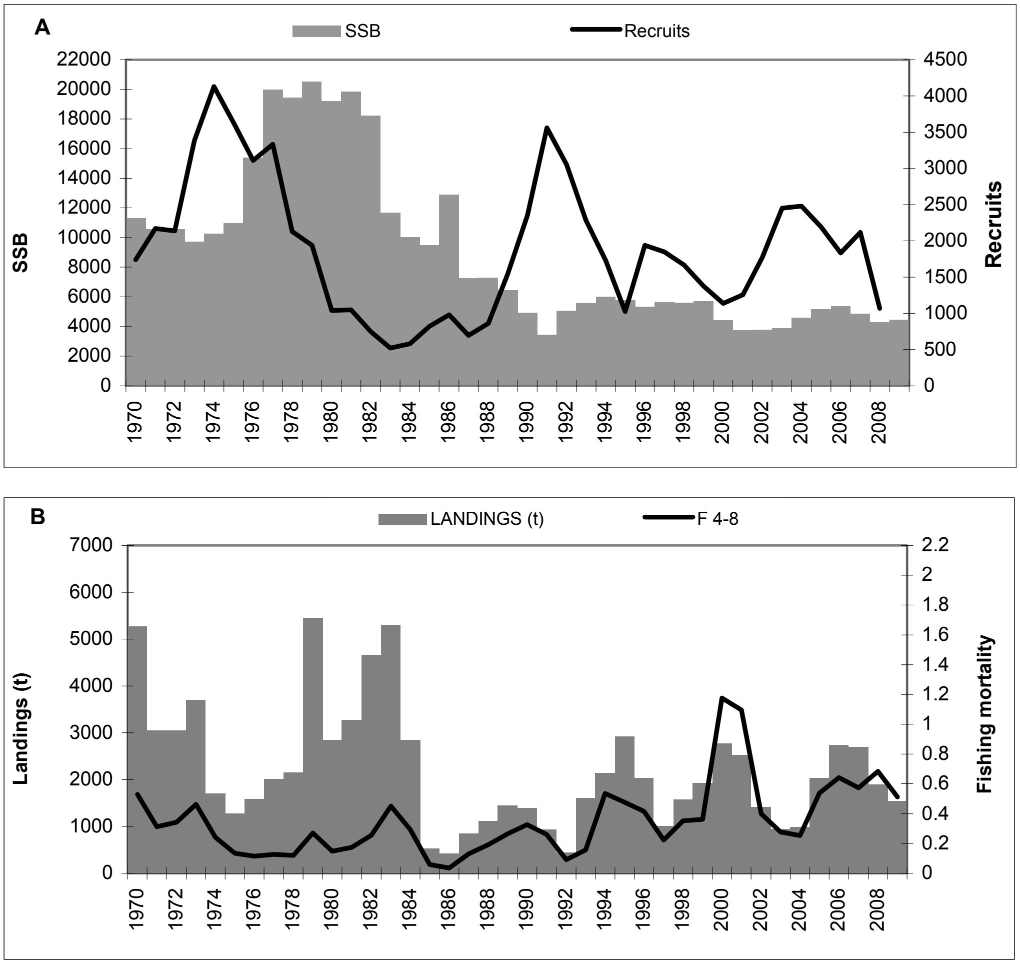


Fig. 4.2.6.3.4. Time-series of turbot population estimates of total stock in the Black Sea including estimated IUU catches (XSA version with terminal F shrinkage): A. recruitment (line) and SSB (grey); B. landings (grey) and average fishing mortality (ages 4–8, line).

XSA outputs including IUU catches are listed in the Tabl. 4.2.6.3.2.

Table 4.2.6.3.2. Turbot in the Black Sea. XSA results and diagnostics including IUU catch.

BLACK SEA TURBOT 1970 - 2009 WITH IUU Catches

Fishing mortality (F) at age

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0.0345	0.0012	0.0011	0.002	0.0009	0.0001	0.0099	0.0093	0.0085	0.0022
3	0.1649	0.0278	0.0667	0.0343	0.0044	0.0048	0.0333	0.0229	0.0323	0.0729
4	0.1341	0.3022	0.0392	0.0743	0.0086	0.0258	0.0198	0.0117	0.0265	0.0698
5	0.4704	0.2216	0.2427	0.3152	0.0754	0.1626	0.1216	0.0572	0.1166	0.3179
6	0.5195	0.2857	0.4133	0.498	0.1998	0.2033	0.1574	0.167	0.1227	0.3035
7	0.7746	0.4649	0.5156	0.972	0.4518	0.1554	0.2098	0.2424	0.2337	0.3666
8	0.7546	0.2864	0.4988	0.452	0.4689	0.1219	0.0672	0.1516	0.1069	0.2978
9	0.5347	0.3139	0.3439	0.4656	0.2421	0.1343	0.1156	0.1264	0.1217	0.2725
10+	0.5347	0.3139	0.3439	0.4656	0.2421	0.1343	0.1156	0.1264	0.1217	0.2725
FBAR 3-7	0.4127	0.2604	0.2555	0.3788	0.148	0.1104	0.1084	0.1002	0.1064	0.2261

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	0	0	0	0	0	0	0	0	0	0.0026
2	0.0087	0.025	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0001	0.0183
3	0.0581	0.0696	0.2191	0.2836	0.1422	0.0029	0.0002	0.0027	0.0001	0.0792
4	0.026	0.0253	0.0842	0.2743	0.1499	0.0083	0.0011	0.0327	0.0006	0.0847
5	0.1449	0.0656	0.3012	0.7913	0.2211	0.0186	0.0233	0.0684	0.102	0.1859
6	0.2446	0.1885	0.2062	0.5546	0.3974	0.0611	0.0319	0.2876	0.2308	0.478
7	0.2134	0.3761	0.3835	0.3509	0.4809	0.1364	0.1172	0.0894	0.238	0.3704
8	0.1114	0.2138	0.2954	0.2775	0.2181	0.0742	0.0027	0.1715	0.3826	0.2082
9	0.1486	0.1745	0.2553	0.4528	0.295	0.0599	0.0353	0.1214	0.1586	0.2186
10+	0.1486	0.1745	0.2553	0.4528	0.295	0.0599	0.0353	0.1214	0.1586	0.2186
FBAR 3-7	0.1374	0.145	0.2388	0.4509	0.2783	0.0455	0.0347	0.0962	0.1143	0.2396

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	0.0095	0.0172	0.0064	0.1018	0.0004	0.0203	0.0441	0	0	0
2	0.05	0.0412	0.0163	0.212	0.0823	0.0528	0.0518	0	0	0
3	0.1407	0.1421	0.0212	0.1873	0.2053	0.0404	0.0404	0.1099	0.0077	0.0619
4	0.3874	0.2641	0.0463	0.1438	0.1656	0.3581	0.148	0.0615	0.06	0.1272
5	0.2875	0.3947	0.0745	0.1312	0.2931	0.6336	0.3311	0.0666	0.1233	0.2494
6	0.1704	0.2207	0.1399	0.1516	0.1836	0.6804	0.6186	0.1522	0.4113	0.5052
7	0.3908	0.2462	0.1014	0.2207	0.4168	0.4086	0.6219	0.4126	0.4846	0.7118
8	0.399	0.1796	0.0963	0.1332	1.6157	0.3028	0.3529	0.4245	0.6789	0.2193
9	0.2464	0.1898	0.0664	0.1525	0.5014	0.3572	0.2585	0.1779	0.2514	0.3175
10+	0.2464	0.1898	0.0664	0.1525	0.5014	0.3572	0.2585	0.1779	0.2514	0.3175
FBAR 3-7	0.2753	0.2536	0.0767	0.1669	0.2529	0.4242	0.352	0.1606	0.2174	0.3311

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	FBAR	**-*
AGE												
1	0.0036	0	0	0.0011	0.0008	0.0008	0.0094	0.0081	0.005	0.0002	0.0044	
2	0.1118	0.0334	0.0885	0.0155	0.0072	0.0269	0.047	0.067	0.045	0.0485	0.0535	
3	0.0992	0.0563	0.246	0.0481	0.0344	0.066	0.0975	0.1711	0.0993	0.0952	0.1219	
4	0.1594	0.1851	0.2038	0.0661	0.0857	0.1769	0.3127	0.5273	0.2802	0.1958	0.3344	
5	0.169	0.4886	0.2762	0.1419	0.1962	0.294	0.4792	0.483	0.3961	0.2462	0.3751	
6	0.4394	1.0824	0.3285	0.2589	0.2909	0.4237	0.6771	0.5127	0.3756	0.3242	0.4042	
7	1.9491	2.0623	0.637	0.6034	0.3167	0.9235	1.4279	0.7473	0.9477	1.0071	0.9007	
8	3.1651	1.6543	0.5542	0.3115	0.3739	0.8736	0.3143	0.5927	1.4157	0.7894	0.9326	
9	1.1057	1.0051	0.3109	0.1641	0.1567	0.2798	0.6032	0.472	0.6728	0.5805	0.5751	
10+	1.1057	1.0051	0.3109	0.1641	0.1567	0.2798	0.6032	0.472	0.6728	0.5805		
FBAR 3-7	0.5632	0.7749	0.3383	0.2237	0.1848	0.3768	0.5989	0.4883	0.4198	0.3737		

Relative F at age

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0.0835	0.0047	0.0043	0.0054	0.0058	0.0006	0.0911	0.0923	0.0797	0.0096
3	0.3995	0.1069	0.2609	0.0907	0.0299	0.0439	0.3073	0.2287	0.3034	0.3226
4	0.3249	1.1604	0.1533	0.1962	0.0584	0.234	0.1831	0.1164	0.2496	0.3085
5	1.1398	0.8508	0.9499	0.8323	0.5094	1.4729	1.122	0.5704	1.0963	1.4056
6	1.2589	1.097	1.6179	1.3147	1.3499	1.8417	1.4522	1.6657	1.1535	1.3421
7	1.8769	1.785	2.018	2.5662	3.0524	1.4075	1.9354	2.4188	2.1971	1.6213
8	1.8286	1.0996	1.9522	1.1934	3.1682	1.1044	0.6202	1.5124	1.0055	1.3169
9	1.2957	1.2052	1.3461	1.2292	1.6354	1.2162	1.0659	1.2609	1.1441	1.205
10+	1.2957	1.2052	1.3461	1.2292	1.6354	1.2162	1.0659	1.2609	1.1441	1.205
REFMEAN	0.4127	0.2604	0.2555	0.3788	0.148	0.1104	0.1084	0.1002	0.1064	0.2261

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	0.0001	0.0001	0	0	0	0.0002	0.0002	0.0001	0.0001	0.011
2	0.0631	0.1725	0.0004	0.0003	0.0006	0.0034	0.0033	0.001	0.0011	0.0764
3	0.4226	0.4798	0.9174	0.6289	0.5109	0.0647	0.0057	0.0279	0.001	0.3305
4	0.1893	0.1744	0.3525	0.6083	0.5386	0.1828	0.0309	0.3398	0.0056	0.3535
5	1.0544	0.4526	1.2611	1.7548	0.7946	0.4081	0.6718	0.7116	0.8922	0.7756
6	1.7802	1.2998	0.8633	1.2299	1.4279	1.3435	0.918	2.9907	2.0191	1.9947
7	1.5535	2.5933	1.6057	0.7781	1.728	3.0009	3.3737	0.93	2.0821	1.5457
8	0.8111	1.474	1.2367	0.6154	0.7839	1.6314	0.0785	1.7833	3.3479	0.8689
9	1.0816	1.2035	1.0691	1.0042	1.0602	1.3165	1.0166	1.2628	1.388	0.9124
10+	1.0816	1.2035	1.0691	1.0042	1.0602	1.3165	1.0166	1.2628	1.388	0.9124
REFMEAN	0.1374	0.145	0.2388	0.4509	0.2783	0.0455	0.0347	0.0962	0.1143	0.2396

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	0.0346	0.0676	0.0834	0.6099	0.0017	0.048	0.1254	0	0	0
2	0.1815	0.1626	0.2131	1.2705	0.3254	0.1245	0.1472	0	0	0
3	0.511	0.5605	0.2766	1.122	0.8119	0.0951	0.1149	0.6846	0.0355	0.187
4	1.4068	1.0415	0.6044	0.8618	0.6547	0.8442	0.4204	0.3831	0.2761	0.3841
5	1.044	1.5566	0.9718	0.7859	1.159	1.4935	0.9406	0.4147	0.5671	0.7532
6	0.6189	0.8702	1.8244	0.908	0.7261	1.6039	1.7574	0.9481	1.8921	1.5257
7	1.4192	0.9711	1.3229	1.3222	1.6483	0.9632	1.7667	2.5694	2.2292	2.1499
8	1.4491	0.7084	1.2566	0.7982	6.3893	0.7139	1.0027	2.6439	3.123	0.6625
9	0.8948	0.7484	0.8659	0.9137	1.9828	0.8421	0.7343	1.1081	1.1564	0.9589
10+	0.8948	0.7484	0.8659	0.9137	1.9828	0.8421	0.7343	1.1081	1.1564	0.9589
REFMEAN	0.2753	0.2536	0.0767	0.1669	0.2529	0.4242	0.352	0.1606	0.2174	0.3311

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	MEAN	**-*
AGE												
1	0.0063	0	0	0.0051	0.0044	0.0021	0.0157	0.0165	0.0119	0.0006	0.0097	
2	0.1985	0.0431	0.2616	0.0691	0.0391	0.0714	0.0784	0.1373	0.1071	0.1299	0.1248	
3	0.1762	0.0726	0.7273	0.2152	0.1861	0.1751	0.1628	0.3505	0.2366	0.2547	0.2806	
4	0.283	0.2388	0.6023	0.2954	0.4636	0.4693	0.5221	1.08	0.6674	0.5238	0.7571	
5	0.3	0.6305	0.8163	0.6344	1.0618	0.7802	0.8003	0.9892	0.9436	0.6589	0.8639	
6	0.7801	1.3968	0.9711	1.1575	1.5744	1.1244	1.1306	1.05	0.8948	0.8675	0.9374	
7	3.4606	2.6613	1.8829	2.6975	1.7141	2.451	2.3843	1.5303	2.2575	2.695	2.1609	
8	5.6196	2.1348	1.6382	1.3924	2.0234	2.3183	0.5249	1.2138	3.3724	2.1124	2.2329	
9	1.9631	1.297	0.9191	0.7334	0.8478	0.7425	1.0073	0.9667	1.6028	1.5534	1.3743	
10+	1.9631	1.297	0.9191	0.7334	0.8478	0.7425	1.0073	0.9667	1.6028	1.5534		
REFMEAN	0.5632	0.7749	0.3383	0.2237	0.1848	0.3768	0.5989	0.4883	0.4198	0.3737		

Stock number at age (start of year) Numbers10^3*

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	1740	2169	2137	3388	4132	3632	3109	3332	2131	1939
2	2124	1439	1793	1767	2801	3417	3003	2571	2755	1762
3	2307	1697	1189	1481	1458	2315	2826	2459	2107	2259
4	1358	1618	1365	920	1184	1201	1905	2260	1988	1687
5	1427	982	989	1085	706	970	968	1544	1847	1601
6	760	737	651	642	655	541	682	708	1206	1360
7	432	374	458	356	322	443	365	482	496	882
8	157	164	194	226	111	170	314	245	313	325
9	91	61	102	98	119	58	124	243	174	232
10+	99	56	115	140	214	79	336	631	290	482
TOTAL	10494	9297	8993	10102	11703	12826	13632	14476	13306	12528

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	1041	1050	747	520	580	821	980	694	860	1545
2	1603	861	868	617	430	480	679	810	574	711
3	1454	1314	694	718	511	355	397	562	670	475
4	1737	1135	1014	461	447	366	293	328	463	554
5	1301	1399	915	771	290	318	300	242	263	383
6	963	931	1084	560	289	192	258	243	187	196
7	830	624	637	729	266	161	150	207	151	123
8	506	554	354	359	425	136	116	110	157	98
9	199	374	370	218	225	282	104	96	77	88
10+	405	608	819	459	592	628	1243	468	492	292
TOTAL	10040	8851	7502	5412	4054	3740	4520	3759	3893	4465

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	2349	3562	3053	2284	1726	1023	1940	1851	1667	1378
2	1274	1924	2895	2509	1706	1427	829	1535	1531	1379
3	578	1002	1527	2355	1678	1299	1119	651	1269	1266
4	363	415	719	1236	1615	1130	1032	889	482	1042
5	421	204	264	568	885	1132	653	736	691	376
6	263	261	113	202	412	546	497	388	569	505
7	101	183	173	82	144	283	229	221	276	312
8	70	56	118	129	54	78	156	102	121	140
9	66	39	39	89	94	9	48	90	55	51
10+	180	39	42	25	28	9	0	21	0	25
TOTAL	5664	7685	8944	9479	8343	6937	6503	6485	6662	6474

YEAR		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	GMST	70-**
AGE														
1	1139	1255	1774	2450	2479	2192	1835	2119	1070	50	0	1679	1911	
2	1140	939	1038	1467	2024	2048	1811	1503	1739	880	42	1388	1580	
3	1140	843	751	786	1194	1662	1649	1429	1162	1375	694	1137	1301	
4	984	854	659	485	619	954	1286	1237	996	870	1033	874	1007	
5	758	694	587	444	376	470	661	778	604	622	592	650	763	
6	242	530	352	368	319	255	290	339	397	336	402	430	508	
7	252	129	148	210	235	197	138	122	168	225	201	260	314	
8	127	30	14	65	95	142	65	27	48	54	68	132	174	
9	93	4	5	6	39	54	49	39	13	10	20	73	111	
10+	28	13	6	4	0	17	0	4	5	0	4			
TOTAL		5904	5290	5332	6285	7380	7991	7784	7597	6201	4423	3056		

Spawning stock number at age (spawning time) Numbers10^3*

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	912	718	493	625	624	991	1193	1043	890	935
4	848	928	893	591	787	791	1259	1500	1309	1087
5	1022	796	793	840	616	810	825	1360	1579	1237
6	559	610	505	477	565	466	601	622	1082	1114
7	279	282	338	209	245	391	314	407	421	700
8	103	136	144	172	84	152	289	217	283	267
9	67	50	82	74	101	51	112	217	156	193

10+	72	45	92	106	180	70	302	565	260	401

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	606	545	267	267	204	152	170	241	288	196
4	1144	748	649	268	277	243	196	215	309	355
5	1096	1227	713	470	235	286	269	212	226	316
6	813	808	932	405	226	178	242	200	159	147
7	711	493	502	584	199	143	134	189	127	97
8	456	475	291	298	363	125	110	96	123	84
9	176	327	311	166	185	261	98	86	67	75
10+	359	532	687	349	487	581	1165	420	433	249

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	231	401	648	920	650	546	471	264	543	527
4	199	243	469	768	993	631	640	575	313	652
5	330	151	230	482	693	747	502	645	589	300
6	230	223	101	179	358	371	348	343	442	374
7	79	155	157	70	111	220	160	172	206	209
8	55	49	108	115	23	64	125	78	82	120
9	56	34	36	79	70	7	40	79	46	41
10+	152	34	39	22	21	7	0	19	0	21

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	466	352	285	329	504	690	674	563	475	562
4	607	520	397	314	396	583	734	634	578	527
5	631	492	463	375	309	368	471	554	449	498
6	185	294	285	308	263	197	197	250	314	272
7	91	44	103	148	191	118	65	80	100	130
8	25	12	10	53	75	87	53	19	22	35
9	51	3	4	6	35	45	34	29	9	7
10+	15	8	5	3	0	14	0	3	4	0

Stock biomass at age (start of year) Tonnes

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	1069	1332	1312	2080	2537	2230	1909	2046	1308	1190
2	2300	1559	1942	1914	3034	3701	3253	2785	2984	1908
3	3797	2793	1956	2438	2400	3810	4651	4048	3468	3719
4	3112	3708	3128	2108	2713	2752	4366	5180	4555	3866
5	4287	2950	2971	3260	2121	2915	2906	4639	5549	4808
6	2835	2751	2428	2394	2443	2020	2545	2643	4500	5072
7	1923	1665	2042	1586	1437	1976	1628	2147	2209	3931
8	811	850	1004	1170	576	877	1623	1266	1617	1678
9	537	358	600	573	700	339	730	1426	1023	1365
10+	735	416	858	1043	1592	589	2504	4706	2161	3594
TOTALBIO	21406	18382	18241	18565	19553	21209	26115	30887	29374	31132

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	639	645	458	319	356	504	602	426	528	772
2	1736	932	940	669	466	520	736	878	622	711
3	2393	2163	1143	1182	840	585	653	924	1103	665
4	3981	2600	2324	1057	1025	839	672	752	1062	997
5	3908	4204	2748	2315	871	956	902	727	789	842
6	3594	3473	4044	2088	1078	717	964	905	697	647
7	3698	2779	2840	3250	1185	715	666	922	671	491
8	2614	2867	1831	1857	2195	703	599	568	809	520
9	1171	2198	2176	1281	1323	1659	613	561	450	583
10+	3024	4538	6104	3422	4416	4682	9271	3489	3669	3533
TOTALBIO	26759	26399	24608	17439	13754	11881	15677	10154	10400	9762

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	1073	1364	2220	1035	1036	92	1191	1137	1024	846
2	930	1495	2742	2240	1297	1027	898	1662	1658	1493
3	720	1156	2178	2591	1796	1238	1119	651	1650	1646
4	644	710	1436	1907	2573	1774	1651	1422	820	1771
5	909	432	698	1185	1844	2513	1372	1546	1521	827
6	852	791	443	599	1069	1634	1391	1086	1765	1566
7	392	780	915	362	604	1254	983	952	1185	1342
8	382	308	747	753	319	470	935	609	727	842
9	428	257	342	742	778	76	455	860	384	356
10+	2215	478	399	235	270	84	0	225	1	240
TOTALBIO	8548	7770	12120	11651	11584	10163	9995	10150	10734	10928

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009

AGE										
1	205	771	1089	1504	1205	351	1139	617	228	1
2	1234	1017	884	1163	1969	1727	1809	1193	993	581
3	1399	1096	963	1015	1707	2195	2485	2000	1576	1588
4	1542	1451	1277	959	1209	1849	2719	2339	1783	1522
5	1686	1596	1486	1067	946	1196	1772	1899	1461	1508
6	695	1642	1125	1147	1015	878	1014	1056	1191	1147
7	987	529	611	855	996	865	618	573	673	946
8	663	169	73	350	549	818	377	166	224	279
9	617	42	31	43	267	405	362	293	71	61
10+	232	165	57	39	1	170	0	37	36	0
TOTALBIO	9259	8478	7597	8141	9864	10453	12296	10175	8237	7632

Spawning stock biomass at age (spawning time) Tonnes

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	1500	1182	812	1029	1028	1631	1963	1717	1464	1539
4	1943	2128	2048	1356	1803	1813	2886	3438	3001	2492
5	3070	2392	2384	2523	1850	2435	2478	4084	4743	3716
6	2085	2274	1883	1779	2108	1740	2243	2319	4036	4156
7	1245	1259	1505	930	1093	1743	1398	1814	1874	3121
8	530	703	746	890	434	787	1497	1119	1461	1379
9	392	292	482	433	591	302	657	1277	918	1136
10+	536	339	689	788	1345	525	2254	4213	1939	2990
TOTSPBIO	11302	10569	10547	9727	10253	10977	15374	19981	19436	20529

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	998	897	440	440	336	251	280	396	473	274
4	2623	1714	1487	615	635	558	448	494	708	638
5	3293	3686	2141	1412	706	858	808	637	679	695
6	3033	3014	3478	1509	843	663	905	748	593	486
7	3170	2196	2236	2600	888	637	599	841	568	389
8	2358	2456	1506	1542	1877	646	570	498	637	447
9	1037	1921	1826	974	1088	1535	575	504	396	498
10+	2677	3966	5124	2602	3634	4333	8686	3131	3232	3020
TOTSPBIO	19188	19849	18238	11694	10007	9482	12871	7248	7287	6447

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	288	462	925	1012	695	521	471	264	705	685
4	354	415	937	1185	1581	990	1024	921	531	1109
5	714	321	609	1005	1443	1658	1053	1354	1295	661
6	746	676	394	530	930	1109	974	960	1370	1160
7	308	658	830	310	467	974	687	738	887	897
8	298	268	678	672	136	385	747	470	494	720
9	361	223	316	656	577	60	381	750	323	289
10+	1868	415	368	208	200	67	0	197	0	195
TOTSPBIO	4937	3437	5056	5578	6030	5766	5337	5654	5606	5716

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	571	457	366	425	720	911	1016	788	644	650
4	950	883	770	619	773	1130	1553	1200	1035	921
5	1404	1132	1172	900	777	935	1263	1352	1086	1208
6	532	911	911	961	837	677	689	779	942	930
7	355	180	424	603	811	520	288	376	400	545
8	130	71	53	286	435	504	307	118	105	179
9	338	24	25	37	236	335	255	221	49	43
10+	127	95	47	34	0	141	0	28	25	0
TOTSPBIO	4408	3754	3767	3866	4588	5154	5372	4861	4284	4477

Stock biomass at age with SOP (start of year) Tonnes

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	1068	1332	1312	2080	2537	2230	1910	2046	1308	1190
2	2300	1559	1942	1914	3033	3701	3254	2785	2984	1908

3	3797	2794	1956	2439	2400	3810	4652	4048	3468	3719
4	3112	3708	3128	2108	2712	2752	4367	5181	4556	3866
5	4287	2950	2970	3261	2120	2915	2907	4640	5550	4808
6	2835	2752	2427	2394	2443	2020	2546	2644	4501	5072
7	1923	1666	2042	1586	1436	1976	1629	2148	2210	3931
8	811	850	1004	1170	576	877	1624	1267	1617	1678
9	537	358	600	573	700	339	730	1427	1023	1365
10+	735	416	858	1043	1592	589	2505	4707	2161	3594
TOTALBIO	21404	18384	18238	18567	19548	21211	26123	30892	29378	31131

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	639	645	458	319	356	504	601	426	528	773
2	1736	932	940	669	466	520	735	877	622	712
3	2393	2164	1143	1182	840	585	653	924	1103	665
4	3981	2601	2323	1057	1025	840	671	752	1062	997
5	3908	4205	2748	2315	871	956	901	727	789	842
6	3594	3473	4043	2089	1078	717	963	905	698	647
7	3699	2780	2840	3250	1185	716	666	922	671	491
8	2614	2867	1831	1857	2195	703	598	568	809	520
9	1171	2198	2176	1281	1323	1659	613	561	450	583
10+	3024	4539	6104	3422	4417	4683	9262	3487	3671	3533
TOTALBIO	26761	26403	24606	17441	13755	11883	15663	10149	10404	9762

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	1060	1339	2219	1035	1036	92	1206	1137	1024	846
2	919	1468	2741	2241	1297	1027	909	1662	1658	1493
3	711	1135	2178	2591	1796	1238	1133	651	1650	1646
4	636	697	1436	1907	2573	1775	1672	1422	820	1771
5	898	424	698	1185	1844	2513	1389	1546	1521	827
6	842	777	443	600	1070	1634	1408	1086	1765	1566
7	387	766	915	363	604	1254	995	952	1185	1342
8	377	302	746	753	319	470	946	609	727	842
9	423	252	342	742	778	76	460	860	384	356
10+	2188	470	399	235	270	84	0	225	1	240
TOTALBIO	8440	7630	12118	11653	11585	10163	10119	10150	10734	10928

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	211	773	1100	1523	1216	352	1157	607	225	0
2	1267	1020	894	1178	1988	1734	1837	1175	981	527
3	1436	1099	973	1028	1723	2205	2524	1969	1558	1440
4	1583	1456	1290	971	1221	1857	2762	2303	1763	1380
5	1731	1601	1501	1080	955	1201	1800	1870	1444	1367
6	714	1647	1137	1161	1025	881	1030	1040	1177	1040
7	1013	531	617	865	1005	869	627	564	665	858
8	681	170	74	355	555	822	383	164	221	253
9	634	42	31	43	270	406	367	289	71	55
10+	238	166	58	39	1	171	0	37	36	0
TOTALBIO	9508	8504	7676	8242	9957	10499	12488	10016	8141	6921

Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	1500	1182	812	1029	1028	1631	1964	1717	1464	1539
4	1943	2128	2047	1356	1803	1813	2887	3438	3001	2492
5	3070	2393	2383	2523	1850	2435	2479	4085	4743	3716
6	2085	2275	1883	1780	2108	1740	2244	2319	4036	4156
7	1245	1259	1505	930	1093	1744	1398	1814	1875	3121
8	530	703	746	890	434	787	1497	1120	1462	1379
9	392	292	482	433	591	302	657	1277	918	1136
10+	536	339	689	788	1345	526	2254	4214	1939	2990
TOTSPBIO	11301	10570	10546	9728	10251	10978	15379	19985	19439	20529

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	998	897	440	440	336	251	280	396	473	274
4	2623	1714	1487	615	635	558	448	494	709	638
5	3293	3686	2141	1412	706	858	807	636	679	695
6	3033	3014	3478	1509	843	663	904	747	593	486
7	3170	2196	2236	2601	888	637	599	841	568	389
8	2358	2457	1506	1542	1877	646	570	497	638	447
9	1037	1921	1826	974	1088	1536	574	504	397	498
10+	2677	3966	5123	2602	3634	4334	8678	3130	3233	3020
TOTSPBIO	19189	19852	18237	11695	10008	9484	12859	7244	7290	6448

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										

1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	285	454	925	1013	695	521	477	264	705	685
4	350	408	937	1185	1581	990	1036	921	531	1109
5	705	315	609	1005	1443	1658	1066	1354	1295	661
6	737	664	394	530	930	1109	986	960	1370	1160
7	304	646	829	310	468	975	696	738	887	897
8	294	263	678	672	136	385	756	470	494	720
9	357	219	315	656	577	60	386	750	323	289
10+	1844	407	368	208	200	67	0	197	0	195
TOTSPBIO	4875	3375	5056	5579	6030	5766	5403	5654	5606	5716

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	587	459	369	431	727	915	1032	776	636	589
4	976	886	778	627	781	1135	1577	1181	1023	835
5	1441	1136	1184	911	784	940	1283	1330	1073	1095
6	546	914	920	973	845	680	700	767	931	844
7	365	180	428	610	818	522	293	370	395	495
8	133	71	54	290	439	506	312	116	104	163
9	348	24	26	38	238	337	259	217	48	39
10+	131	96	47	34	1	142	0	28	24	0
TOTSPBIO	4526	3766	3806	3913	4631	5177	5456	4785	4234	4059

Summary (without SOP correction)

Age	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3-7
1970	1740	21406	11302	5273	0.4666	0.4127
1971	2169	18382	10569	3052	0.2888	0.2604
1972	2137	18241	10547	3049	0.2891	0.2555
1973	3388	18565	9727	3705	0.3809	0.3788
1974	4132	19553	10253	1696	0.1654	0.148
1975	3632	21209	10977	1273	0.116	0.1104
1976	3109	26115	15374	1584	0.103	0.1084
1977	3332	30887	19981	2012	0.1007	0.1002
1978	2131	29374	19436	2160	0.1111	0.1064
1979	1939	31132	20529	5447	0.2653	0.2261
1980	1041	26759	19188	2843	0.1482	0.1374
1981	1050	26399	19849	3276	0.165	0.145
1982	747	24608	18238	4662	0.2556	0.2388
1983	520	17439	11694	5307	0.4538	0.4509
1984	580	13754	10007	2852	0.285	0.2783
1985	821	11881	9482	527	0.0556	0.0455
1986	980	15677	12871	428	0.0333	0.0347
1987	694	10154	7248	849	0.1171	0.0962
1988	860	10400	7287	1116	0.1531	0.1143
1989	1545	9762	6447	1452	0.2252	0.2396
1990	2349	8548	4937	1392	0.2819	0.2753
1991	3562	7770	3437	935	0.272	0.2536
1992	3053	12120	5056	438	0.0866	0.0767
1993	2284	11651	5578	1601	0.287	0.1669
1994	1726	11584	6030	2139	0.3547	0.2529
1995	1023	10163	5766	2924	0.5072	0.4242
1996	1940	9995	5337	2031	0.3806	0.352
1997	1851	10150	5654	1014	0.1793	0.1606
1998	1667	10734	5606	1574	0.2807	0.2174
1999	1378	10928	5716	1933	0.3382	0.3311
2000	1139	9259	4408	2776	0.6298	0.5632
2001	1255	8478	3754	2522	0.6718	0.7749
2002	1774	7597	3767	1412	0.3748	0.3383
2003	2450	8141	3866	943	0.244	0.2237
2004	2479	9864	4588	989	0.2155	0.1848
2005	2192	10453	5154	2039	0.3956	0.3768
2006	1835	12296	5372	2737	0.5095	0.5989
2007	2119	10175	4861	2692	0.5538	0.4883
2008	1070	8237	4284	1901	0.4438	0.4198
2009	50	7632	4477	1541	0.3442	0.3737

Arith.						
Mean	1844	14937	8966	2202	0.2882	0.2685
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Summary (with SOP correction)

Age	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 3-7
1970	1740	21404	11301	5273	0.4666	0.9999	0.4127
1971	2169	18384	10570	3052	0.2887	1.0001	0.2604
1972	2137	18238	10546	3049	0.2891	0.9999	0.2555
1973	3388	18567	9728	3705	0.3808	1.0001	0.3788
1974	4132	19548	10251	1696	0.1654	0.9998	0.148
1975	3632	21211	10978	1273	0.116	1.0001	0.1104
1976	3109	26123	15379	1584	0.103	1.0003	0.1084
1977	3332	30892	19985	2012	0.1007	1.0002	0.1002
1978	2131	29378	19439	2160	0.1111	1.0001	0.1064
1979	1939	31131	20529	5447	0.2653	1	0.2261
1980	1041	26761	19189	2843	0.1482	1.0001	0.1374
1981	1050	26403	19852	3276	0.165	1.0002	0.145
1982	747	24606	18237	4662	0.2556	0.9999	0.2388
1983	520	17441	11695	5307	0.4538	1.0001	0.4509
1984	580	13755	10008	2852	0.285	1.0001	0.2783
1985	821	11883	9484	527	0.0556	1.0002	0.0455
1986	980	15663	12859	428	0.0333	0.9991	0.0347
1987	694	10149	7244	849	0.1172	0.9995	0.0962
1988	860	10404	7290	1116	0.1531	1.0004	0.1143
1989	1545	9762	6448	1452	0.2252	1.0001	0.2396
1990	2349	8440	4875	1392	0.2855	0.9875	0.2753
1991	3562	7630	3375	935	0.277	0.982	0.2536
1992	3053	12118	5056	438	0.0866	0.9999	0.0767
1993	2284	11653	5579	1601	0.287	1.0002	0.1669
1994	1726	11585	6030	2139	0.3547	1.0001	0.2529
1995	1023	10163	5766	2924	0.5071	1	0.4242
1996	1940	10119	5403	2031	0.3759	1.0124	0.352
1997	1851	10150	5654	1014	0.1793	1	0.1606
1998	1667	10734	5606	1574	0.2808	0.9999	0.2174
1999	1378	10928	5716	1933	0.3382	1	0.3311
2000	1139	9508	4526	2776	0.6133	1.0268	0.5632
2001	1255	8504	3766	2522	0.6697	1.0031	0.7749
2002	1774	7676	3806	1412	0.371	1.0104	0.3383
2003	2450	8242	3913	943	0.241	1.0124	0.2237
2004	2479	9957	4631	989	0.2135	1.0094	0.1848
2005	2192	10499	5177	2039	0.3939	1.0044	0.3768
2006	1835	12488	5456	2737	0.5016	1.0157	0.5989
2007	2119	10016	4785	2692	0.5626	0.9844	0.4883
2008	1070	8141	4234	1901	0.449	0.9883	0.4198
2009	50	6921	4059	1541	0.3796	0.9068	0.3737

Arith.

Mean 1844 14929 8961 2202 0.2887 0.2685

Units (Thousands) (Tonnes) (Tonnes) (Tonnes)

Lowestoft	VPA	Version	3.1										
	Extended	Survivors	Analysis										
	BLACK	SEA	TURBOT	1970-2009 WITH IUU CATCHES									
	Catch	data	for	40	years.	1970	to	2009	Ages	1	to	10	
	Fleet	First	Last	First	Last	Alpha	Beta						
	year	year	age	age									
	RO	Trawl	fleet	2003	2009	2	7	0.25	0.8				UKR
	Trawl	survey	1989	2009	2	9	0.25	0.8				BG	Trawl
	fleet	2006	2009	2	9	0.25	0.8				TR	CPUE	1987
	2009	2	9	0.25	0.8								

Time series weights :
Tapered time weighting not applied
Catchability analysis :
Catchability dependent on stock size for ages < 3
Regression type = C

Minimum of 5 points used for regression

Survivor estimates shrunk to the population mean for ages < 3
Catchability independent of age for ages >= 5
Terminal population estimation :
Survivor estimates shrunk towards the mean F

of the final 5 years or the 5 oldest ages.
S.E. of the mean to which the estimates are shrunk = 0.5

Minimum standard error for population

estimates derived from each fleet = 0.3
Prior weighting not applied

Tuning had not converged after 30 iterations
Total absolute residual between iterations

29 and 30 = 0.00015

Final year F values

	Age	1	2	3	4	5	6	7	8	9
Iteration	29	0.0002	0.0485	0.0952	0.1958	0.2463	0.3242	1.0072	0.7895	0.5806
Iteration	30	0.0002	0.0485	0.0952	0.1958	0.2462	0.3242	1.0071	0.7894	0.5805

Regression weights

1 1 1 1 1 1 1 1 1 1

Fishing mortalities

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
1	0.004	0	0	0.001	0.001	0.001	0.009	0.008	0.005	0		2
0.112	0.033	0.089	0.015	0.007	0.027	0.047	0.067	0.045	0.049		3	0.099
0.056	0.246	0.048	0.034	0.066	0.097	0.171	0.099	0.095		4	0.159	0.185
0.204	0.066	0.086	0.177	0.313	0.527	0.28	0.196		5	0.169	0.489	0.276
0.142	0.196	0.294	0.479	0.483	0.396	0.246		6	0.439	1.082	0.329	0.259
0.291	0.424	0.677	0.513	0.376	0.324		7	1.949	2.062	0.637	0.603	0.317
0.924	1.428	0.747	0.948	1.007		8	3.165	1.654	0.554	0.311	0.374	0.874
0.314	0.593	1.416	0.789		9	1.106	1.005	0.311	0.164	0.157	0.28	0.603
0.472	0.673	0.581										

XSA population numbers (Thousands)

AGE

YEAR	1	2	3	4	5	6	7	8	9			
2000	1.14E+03	1.14E+03	1.14E+03	9.84E+02	7.58E+02	2.42E+02	2.52E+02	1.27E+02	9.32E+01			2001
1.26E+03	9.39E+02	8.43E+02	8.54E+02	6.94E+02	5.30E+02	1.29E+02	2.97E+01	4.42E+00			2002	1.77E+03
1.04E+03	7.51E+02	6.59E+02	5.87E+02	3.52E+02	1.48E+02	1.36E+01	4.70E+00			2003	2.45E+03	1.47E+03
7.86E+02	4.85E+02	4.44E+02	3.68E+02	2.10E+02	6.49E+01	6.45E+00			2004	2.48E+03	2.02E+03	1.19E+03
6.19E+02	3.76E+02	3.19E+02	2.35E+02	9.48E+01	3.93E+01			2005	2.19E+03	2.05E+03	1.66E+03	9.54E+02
4.70E+02	2.55E+02	1.97E+02	1.42E+02	5.39E+01			2006	1.83E+03	1.81E+03	1.65E+03	1.29E+03	6.61E+02
2.90E+02	1.38E+02	6.47E+01	4.89E+01			2007	2.12E+03	1.50E+03	1.43E+03	1.24E+03	7.78E+02	3.39E+02
1.22E+02	2.74E+01	3.91E+01			2008	1.07E+03	1.74E+03	1.16E+03	9.96E+02	6.04E+02	3.97E+02	1.68E+02
4.77E+01	1.25E+01			2009	5.05E+01	8.80E+02	1.37E+03	8.70E+02	6.22E+02	3.36E+02	2.25E+02	5.38E+01
9.57E+00												

Estimated population abundance at 1st Jan 2010

0.00E+00 4.17E+01 6.94E+02 1.03E+03 5.92E+02 4.02E+02 2.01E+02 6.81E+01 2.02E+01
Taper weighted geometric mean of the VPA populations:

1.52E+03 1.38E+03 1.14E+03 8.77E+02 6.48E+02 4.27E+02 2.57E+02 1.26E+02 6.61E+01
Standard error of the weighted Log(VPA populations) :

0.7647 0.5313 0.534 0.5482 0.5768 0.5775 0.6007 0.8123 1.1348
Log catchability residuals.

Fleet: RO Trawl fleet

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
2	99.99	99.99	99.99	0.27	-0.01	-0.59	-0.75	-0.54	1.77	-0.14		3
99.99	99.99	99.99	0.26	-0.22	-0.47	-0.47	-0.05	0.97	-0.03		4	99.99
99.99	99.99	-0.1	-0.55	-0.31	-0.28	0.37	0.86	0.02		5	99.99	99.99
99.99	-0.2	0.16	-0.05	0.28	-0.18	0.22	-0.24		6	99.99	99.99	99.99
0.3	0.43	-0.34	0.02	-0.48	-0.41	-0.19		7	99.99	99.99	99.99	0.64
-0.52	-0.05	0.05	0.22	-0.17	0.06		8	No	data	for	this	fleet
at	this	age				9	No	data	for	this	fleet	at
this	age											

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7
Mean Log	q	-2.422	-1.629	-1.2511	-1.2511	-1.2511
S.E(Log | q)	0.4992	0.4759	0.2199	0.3704	0.3574

Regression statistics :
Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Log	q
2	1.03	-0.02	3.61	0.1	7	0.94	-3.7				

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Q		
3	-7.75	-1.613	43.87	0.01	7	3.44	-2.42					4
0.68	0.827	3.26	0.58	7	0.33	-1.63					5	1.08
-0.201	0.83	0.54	7	0.26	-1.25					6	0.98	0.02
1.44	0.15	7	0.38	-1.35					7	1.46	-0.51	-0.6
0.2	7	0.55	-1.22									

Fleet: UKR Trawl survey

Age	1987	1988	1989									
2	99.99	99.99	0.83									3
99.99	99.99	0.87									4	99.99
99.99	-0.2									5	99.99	99.99
-0.18									6	99.99	99.99	0.78
							7	99.99	99.99	0.52		
					8	99.99	99.99	-0.06				
			9	99.99	99.99	-0.01						

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
2	-1.08	0.99	1.86	0.73	0.95	99.99	99.99	99.99	99.99	99.99		3
-0.65	0.38	0.56	-0.35	-0.04	99.99	99.99	99.99	-1.27	99.99		4	-0.26
0.68	-0.06	-0.81	-1.1	99.99	99.99	99.99	-0.33	99.99		5	-1.17	0.38
0.06	-0.2	-0.6	99.99	99.99	99.99	-0.36	99.99		6	-0.49	0.01	1.08
0.41	-0.32	99.99	99.99	99.99	0.78	99.99		7	0.67	0.09	0.33	1.31
0.81	99.99	99.99	99.99	0.98	99.99		8	0.51	-0.3	-0.77	0.68	2.25
99.99	99.99	99.99	1.26	99.99		9	0.2	-0.04	0.16	0.91	1	99.99
99.99	99.99	0.62	99.99									

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
2	99.99	1.1	99.99	-0.15	-1.4	-0.38	-2.5	-0.95	99.99	99.99		3
99.99	0.75	0.81	-0.19	-0.15	-1.13	0.07	0.33	99.99	99.99		4	99.99
0.31	0.39	-0.13	0.3	-0.87	1.03	1.04	99.99	99.99		5	99.99	0.16
0.36	0.18	0.37	-0.09	0.59	0.49	99.99	99.99		6	99.99	-0.5	0.58
0.89	0.97	0.67	1.04	0.58	99.99	99.99		7	99.99	-0.22	1.4	2
1.45	1.84	1.81	1.36	99.99	99.99		8	99.99	-0.89	1.69	1.59	1.45
1.84	0.15	1.29	99.99	99.99		9	99.99	0.7	1.1	0.94	1.06	0.87
0.84	1.16	99.99	99.99									

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

	Age	3	4	5	6	7	8	9
Mean Log	q	-3.9047	-2.7593	-1.999	-1.999	-1.999	-1.999	-1.999
S.E(Log q)	0.6814	0.6693	0.4802	0.7374	1.2646	1.2847	0.8224	

Regression statistics :
Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Log	q
2	1.48	-0.469	4.33	0.09	12	1.35	-5.33				

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Q		
3	2.1	-1.31	0.47	0.11	14	1.39	-3.9					4
1.16	-0.335	2.15	0.27	14	0.8	-2.76					5	1.12
-0.324	1.5	0.38	14	0.56	-2					6	1.82	-1.236
-1.87	0.16	14	1	-1.54					7	0.72	0.656	2.09
0.32	14	0.51	-0.97					8	1.12	-0.255	0.87	0.27
14	1.18	-1.23					9	1.13	-1.027	1.04	0.84	14
0.48	-1.32											

Fleet : BG Trawl fleet

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
2	99.99	99.99	99.99	99.99	99.99	99.99	0.35	0.25	0.44	-1.04		3
99.99	99.99	99.99	99.99	99.99	99.99	-0.03	0.34	-0.15	-0.16		4	99.99
99.99	99.99	99.99	99.99	99.99	-0.91	0.63	0.32	-0.05		5	99.99	99.99
99.99	99.99	99.99	99.99	-1.38	0.34	0.85	0.18		6	99.99	99.99	99.99
99.99	99.99	99.99	-0.96	0.34	0.75	0.43		7	99.99	99.99	99.99	99.99
99.99	99.99	-0.7	-0.36	-0.2	-0.04		8	99.99	99.99	99.99	99.99	99.99
99.99	-0.9	-0.56	-0.1	-0.32		9	99.99	99.99	99.99	99.99	99.99	99.99
-1.57	99.99	0.18	-0.09									

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

	Age	3	4	5	6	7	8	9
Mean Log	q	-2.2873	-1.9148	-1.6591	-1.6591	-1.6591	-1.6591	-1.6591
S.E(Log	q)	0.2319	0.6656	0.9626	0.7706	0.4709	0.6435	1.1211

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Log	q
2	0.33	8.09	5.85	0.99	4	0.05	-2.94				

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Q		
3	0.65	0.489	4	0.5	4	0.18	-2.29					4
7.5	-0.35	-31.08	0	4	5.94	-1.91					5	7.17
-0.144	-28.2	0	4	8.41	-1.66					6	0.16	3.19
5.15	0.88	4	0.06	-1.52					7	0.56	1.581	3.34
0.87	4	0.13	-1.98					8	1.19	-0.242	1.81	0.46
4	0.49	-2.13					9	-30.3	-3.29	25.28	0.01	3
11.76	-2.15											

Fleet : TR CPUE

Age	1987	1988	1989									
2	-0.41	-0.01	1.29									3
-3.01	-2.98	2.21									4	-1.31
-4.47	1.23									5	0.07	-3.34
0.99									6	0.6	1.52	2.17
							7	1.99	2.16	2.73		
					8	1.43	2	2.19				
			9	1.53	3.05	1.58						

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999		
2	0.98	0.92	0.08	0.55	-0.12	0.9	1.47	-1.4	-1.3	-1.34		3
2.95	3.04	1.49	2.21	2.91	2.5	0.76	-6.79	-7.12	-7.67		4	1.89
2.66	0.02	0.8	1.91	0.59	-0.9	-0.27	-1.19	-0.44		5	1.23	2.24
0.17	-0.2	1.46	1.74	-0.07	-1.21	-1.34	0.25		6	1.54	1.53	0.5
-0.02	2.08	2.94	0.61	-0.64	0.05	-0.32		7	1.68	1.65	-0.18	0.03
2.07	2.77	1.61	0.2	1.69	1.15		8	1.81	2.54	0.31	-1.05	3.3
2.96	1.08	1.3	2.01	1.47		9	1.45	1.45	0.98	-0.66	2.07	3.63
1.39	0.53	2.01	0.78									

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
2	0.52	-1.03	-1.09	0.11	0.02	-0.29	0.35	0.55	0.08	-0.84		3
2.37	0.35	0.83	0.57	0.19	0.58	1.32	1.39	1.26	0.63		4	0.57
-1.05	-0.26	-0.24	-0.3	0.43	0.11	0.49	-0.46	0.21		5	0.25	-0.43
-1.27	-1.07	-0.55	0.34	0.27	0.69	0.04	-0.26		6	1.33	0.76	-0.57
-0.3	-0.16	0.66	0.88	0.8	-0.26	-0.32		7	1.71	2.91	0.09	0.78
0.34	0.43	1.5	1.28	0.56	-0.38		8	3.88	3.05	2.1	1.87	0.9
0.55	1.55	1.68	0.37	0.61		9	2.64	3.09	0.55	2.32	1.05	0.8
0.33	-0.78	0.19	-5.07									

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

	Age	3	4	5	6	7	8	9
Mean Log	q	-3.3048	-1.4454	-0.5635	-0.5635	-0.5635	-0.5635	-0.5635
S.E(Log	q)	3.245	1.4032	1.1923	1.1866	1.6096	2.0176	2.0724

Regression statistics :

Ages	with	q	dependent	on	year	class	strength				
	Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Log	q
	2	0.25	1.649	6.87	0.19	23	0.88	-5.87				

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No	Pts	Reg	s.e	Mean	Q		
3	0.4	0.881	5.49	0.09	23	1.32	-3.3					4
0.63	0.88	3.38	0.21	23	0.88	-1.45					5	0.8
0.426	1.68	0.18	23	0.98	-0.56					6	1.51	-0.65
-3.1	0.07	23	1.49	0.11					7	1.12	-0.176	-1.4
0.09	23	1.12	0.69					8	1.82	-1.201	-5.53	0.09
23	2	1.08					9	0.88	0.361	-0.04	0.31	23
1.58	0.52											

Terminal year survivor and F summaries:

Age 1 Catchability dependent on age and year class strength

Year class = 2008

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
Survivors	s.e	s.e	Ratio	Weights	F							
RO	Trawl	fleet	1	0	0	0	0	0	0			UKR
Trawl	survey	1	0	0	0	0	0	0			BG	Trawl
fleet	1	0	0	0	0	0	0			TR	CPUE	1
0	0	0	0	0	0							
P	shrinkage	mean	1380	0.53	0.47	0						F
shrinkage	mean	2	0.5	0.53	0.005							

Weighted prediction :

Survivors	Int	Ext	N	Var	F	
at	end	of	year	s.e	s.e	Ratio
42	0.36	4.98	2	13.667	0	

Age 2 Catchability dependent on age and year class strength

Year class = 2007

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
Survivors	s.e	s.e	Ratio	Weights	F		

	RO	Trawl	fleet	602	1.053	0	0	1	0.078	0.056			UKR
	Trawl	survey	1	0	0	0	0	0	0				
BG	Trawl	fleet	246	0.778	0	0	1	0.142	0.131			TR	CPUE
	301	0.928	0	0	1	0.1	0.109						
	P	shrinkage	mean	1143	0.53	0.318	0.03						F
	shrinkage	mean	874	0.5	0.362	0.039							
	Weighted	prediction	:										
	Survivors	Int	Ext	N	Var	F							
	at	end	of	year	s.e	s.e	Ratio						
	694	0.3	0.47	5	1.586	0.049							
	Age	3	Catchability		constant	w.r.t.	time	and	dependent	on	age		
	Year	class	=	2006									
Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated						
	Survivors	s.e	s.e	Ratio	Weights	F							
	RO	Trawl	fleet	1292	0.493	0.631	1.28	2	0.182	0.077			UKR
	Trawl	survey	1	0	0	0	0	0	0			BG	Trawl
	fleet	946	0.28	0.198	0.71	2	0.565	0.104			TR	CPUE	1162
	0.865	0.143	0.16	2	0.057	0.085							
	F	shrinkage	mean	1048	0.5	0.196	0.094						
	Weighted	prediction	:										
	Survivors	Int	Ext	N	Var	F							
	at	end	of	year	s.e	s.e	Ratio						
	1033	0.21	0.14	7	0.639	0.095							
	Age	4	Catchability		constant	w.r.t.	time	and	dependent	on	age		
	Year	class	=	2005									
	Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
	Survivors	s.e	s.e	Ratio	Weights	F							
	RO	Trawl	fleet	839	0.348	0.381	1.09	3	0.28	0.142			UKR
	Trawl	survey	228	1.44	0	0	1	0.015	0.446			BG	Trawl
	fleet	540	0.262	0.086	0.33	3	0.474	0.213			TR	CPUE	959
	0.747	0.169	0.23	3	0.057	0.125							
	F	shrinkage	mean	399	0.5	0.174	0.278						
	Weighted	prediction	:										
	Survivors	Int	Ext	N	Var	F							
	at	end	of	year	s.e	s.e	Ratio						
	592	0.19	0.14	11	0.739	0.196							
	Age	5	Catchability		constant	w.r.t.	time	and	dependent	on	age		
	Year	class	=	2004									
	Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
	Survivors	s.e	s.e	Ratio	Weights	F							
	RO	Trawl	fleet	386	0.231	0.247	1.07	4	0.472	0.255			UKR
	Trawl	survey	356	0.644	1.037	1.61	2	0.043	0.274			BG	Trawl
	fleet	556	0.257	0.025	0.1	4	0.289	0.184			TR	CPUE	402
	0.651	0.243	0.37	4	0.052	0.247							
	F	shrinkage	mean	249	0.5	0.144	0.372						
	Weighted	prediction	:										
	Survivors	Int	Ext	N	Var	F							
	at	end	of	year	s.e	s.e	Ratio						
	402	0.16	0.12	15	0.788	0.246							
	Age	6	Catchability constant		w.r.t. time and age (fixed at the			value for age) 5					
	Year	class	=	2003									
	Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
	Survivors	s.e	s.e	Ratio	Weights	F							
	RO	Trawl	fleet	204	0.209	0.133	0.64	5	0.52	0.32			UKR
	Trawl	survey	328	0.467	0.387	0.83	3	0.053	0.211			BG	Trawl
	fleet	249	0.28	0.181	0.65	4	0.203	0.269			TR	CPUE	181
	0.616	0.162	0.26	5	0.055	0.354							
	F	shrinkage	mean	132	0.5	0.169	0.459						
	Weighted	prediction	:										
	Survivors	Int	Ext	N	Var	F							
	at	end	of	year	s.e	s.e	Ratio						
	201	0.15	0.09	18	0.583	0.324							
	Age	7	Catchability constant		w.r.t. time and age (fixed at the			value for age) 5					
	Year	class	=	2002									
	Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
	Survivors	s.e	s.e	Ratio	Weights	F							

RO	Trawl	fleet	58	0.193	0.089	0.46	6	0.466	1.116			UKR
Trawl	survey	84	0.346	0.461	1.33	4	0.078	0.877			BG	Trawl
fleet	70	0.392	0.249	0.64	4	0.138	0.987			TR	CPUE	67
0.594	0.167	0.28	6	0.042	1.018							
F	shrinkage	mean	84	0.5	0.277	0.881						

Weighted	prediction	:				
Survivors	Int	Ext	N	Var	F	
at	end	of	year	s.e	s.e	Ratio
68	0.18	0.08	21	0.462	1.007	

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2001

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
Survivors	s.e	s.e	Ratio	Weights	F							
RO	Trawl	fleet	18	0.195	0.121	0.62	6	0.31	0.866			UKR
Trawl	survey	25	0.322	0.277	0.86	5	0.07	0.682			BG	Trawl
fleet	16	0.425	0.157	0.37	4	0.174	0.938			TR	CPUE	33
0.715	0.096	0.13	7	0.039	0.55							
F	shrinkage	mean	23	0.5	0.407	0.721						

Weighted	prediction	:				
Survivors	Int	Ext	N	Var	F	
at	end	of	year	s.e	s.e	Ratio
20	0.23	0.07	23	0.302	0.789	

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2000

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated					
Survivors	s.e	s.e	Ratio	Weights	F							
RO	Trawl	fleet	5	0.197	0.107	0.54	5	0.167	0.557			UKR
Trawl	survey	6	0.329	0.293	0.89	5	0.043	0.431			BG	Trawl
fleet	4	0.56	0.122	0.22	4	0.134	0.678			TR	CPUE	0
1.094	1.039	0.95	8	0.039	0							
F	shrinkage	mean	5	0.5	0.616	0.516						

Weighted	prediction	:				
Survivors	Int	Ext	N	Var	F	
at	end	of	year	s.e	s.e	Ratio
4	0.32	0.17	23	0.523	0.581	

4.2.7 Short term prediction

Given the uncertainties of actual catches the WG did not undertake short term projections.

4.2.8 Medium term prediction

Given the uncertainties of actual catches the WG did not undertake medium term projections.

4.2.9 Long term prediction Method 1: Yield per Recruit

4.2.9.1 Justification

In order to estimate and propose reference points to fisheries management consistent with high long term yields, STECF SG Black Sea-10-01 applied Yield per Recruit and Production models.

4.2.9.2 Input parameters

Table 4.2.9.1.1 and 4.2.9.1.2 show the input parameters to the YPR analysis. They are derived from long term means of the XSA input data (2000-2009) except the exploitation pattern, which was estimated as the 2009 exploitation pattern rescaled to the average of the years 2007-2009. Exploitation pattern from both XSA estimates based on official landings and with IUU are used.

Table 4.2.9.1.1. Turbot in the Black Sea. Input parameters to YPR analysis from official landings.

age min	age group	stock weight	catch weight	maturity	F	M
1	1	0.3272	0.3272	0	0.0069	0.19
age max	2	0.7737	0.7737	0	0.0647	0.19
10	3	1.327	1.327	0.45	0.1336	0.19
Fref 4-8	4	1.8616	1.8616	0.7	0.3588	0.19
0.5503	5	2.4481	2.4481	0.95	0.3595	0.19
	6	3.1938	3.1938	1	0.4404	0.19
	7	4.2219	4.2219	1	0.7993	0.19
	8	5.5083	5.5083	1	0.7935	0.19
	9	7.054	7.054	1	0.5327	0.19
	10	9.6351	9.6351	1	0.5327	0.19

Table 4.2.9.1.2 Turbot in the Black Sea. Input parameters to YPR analysis from IUU estimates.

age min	age group	stock weight	catch weight	maturity	F	M
1	1	0.3272	0.3272	0	0.0039	0.19
age max	2	0.7737	0.7737	0	0.0465	0.19
10	3	1.327	1.327	0.45	0.1060	0.19
Fref 4-8	4	1.8616	1.8616	0.7	0.2908	0.19
0.5125	5	2.4481	2.4481	0.95	0.3262	0.19
	6	3.1938	3.1938	1	0.3515	0.19
	7	4.2219	4.2219	1	0.7832	0.19
	8	5.5083	5.5083	1	0.8110	0.19
	9	7.054	7.054	1	0.5001	0.19
	10	9.6351	9.6351	1	0.5001	0.19

4.2.9.3 Results

Fmax was estimated as 0.303 and 0.307 from YpR curves estimated based on exploitation paterns from the two XSA assessments (Fig. 4.2.9.3.1 and Fig. 4.2.9.3.2.). $F_{0.1}$ were estimated at 0.16 and 0.164 (Table 4.2.9.3.1 and Table 4.2.9.3.2).

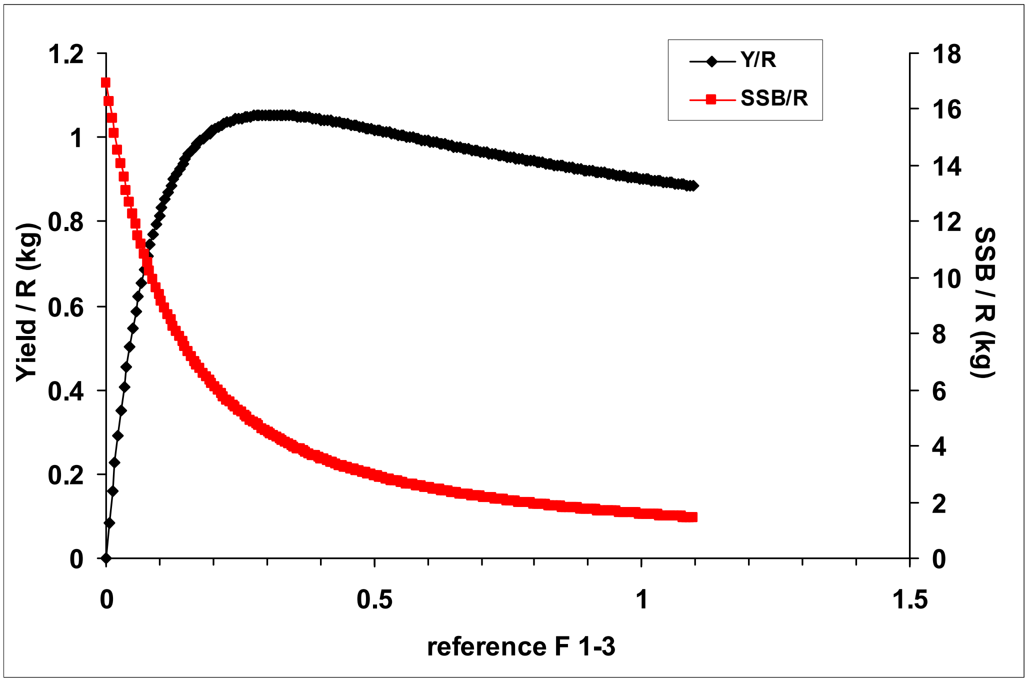


Fig. 4.2.9.3.1 Turbot in the Black Sea. YpR and SSBpR from official landings with increasing fishing mortality (average of ages 4-8 y). Fmax= 0.303.

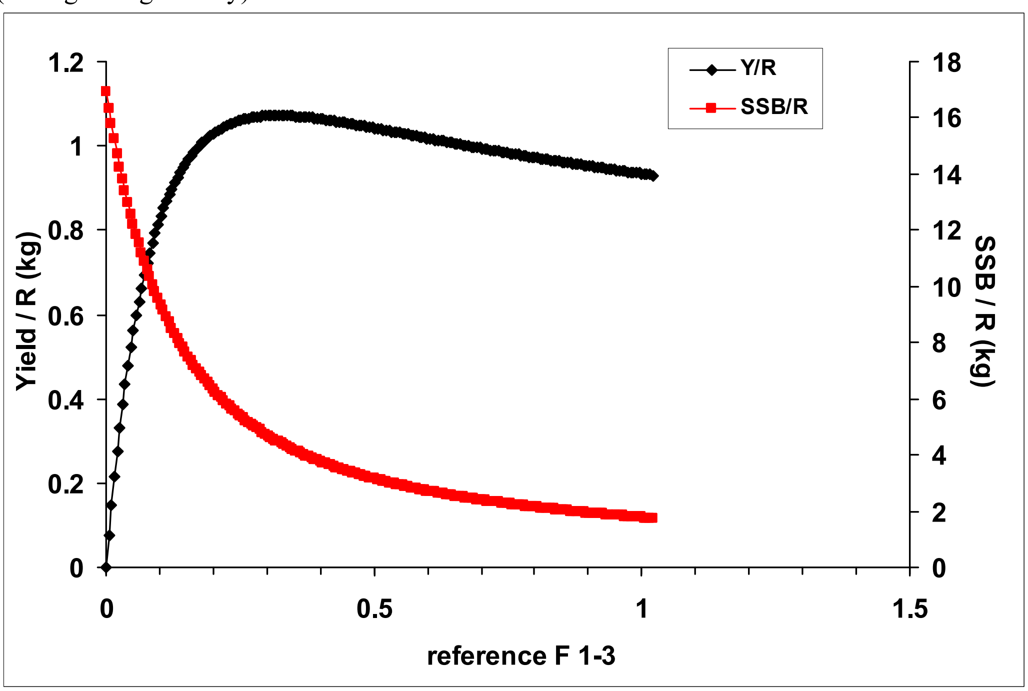


Fig. 4.2.9.3.2. Turbot in the Black Sea. YpR and SSBpR from official landings with increasing fishing mortality (average of ages 4-8 y). Fmax= 0.307.

4.2.10 Long term prediction method 2: Age-strucutred production model

4.2.10.1 Justification

The estimation of reference points requires the application of an age-structured production model.

4.2.10.2 Input parameters

Tables 4.2.10.1.1 and 4.2.10.1.2. list all input parameters used to estimate MSY, Fmsy and Bmsy. Such parameters were derived from the two XSA assessments described in the previous sections and present long term means with the exception of the exploitation pattern, which was estimated as the 2009 exploitation pattern rescaled to the average of the years 2007-2009. The recruitment was estimated applying the Ricker function shown in Figs. 4.2.10.1.1 and 4.2.10.1.2. A reasonably close relationships between the SSB and recruitment appear.

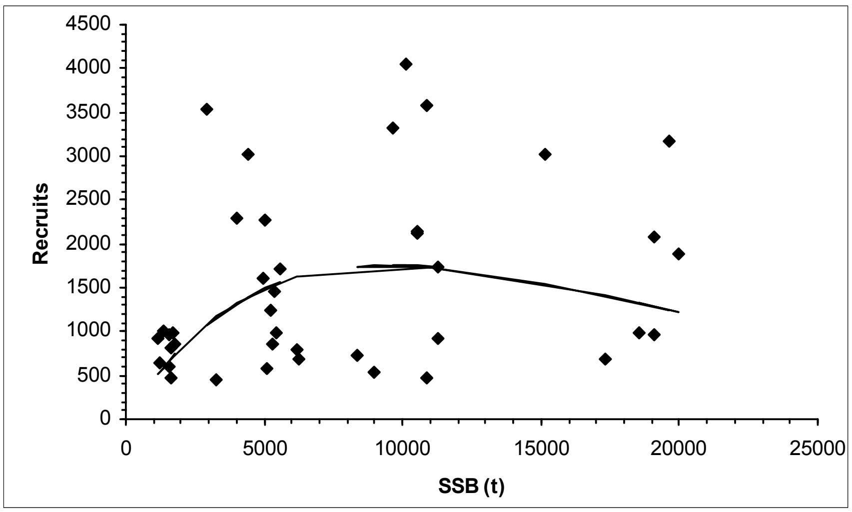


Fig. 4.2.10.1.1. Turbot in the Black Sea from XSA using official landings. Spawning stock - recruitment relationship expressed as the Ricker function. Parameters are given in Table 4.2.10.1.1.

Table 4.2.10.1.1. Turbot in the Black Sea from XSA using official landings. Input parameters to the production model.

age min	age group	stock weight	catch weight	maturity	F	M	R=a*SSB*exp(-SSB/k)	
1	1	0.3272	0.3272	0	0.0069	0.19	a=	1.18
age max	2	0.7737	0.7737	0	0.0647	0.19	k=	15.53
10	3	1.327	1.327	0.45	0.1336	0.19	sterror=	0.30729547
Fref	4	1.8616	1.8616	0.7	0.3588	0.19		
0.5503	5	2.4481	2.4481	0.95	0.3595	0.19		
	6	3.1938	3.1938	1	0.4404	0.19		
	7	4.2219	4.2219	1	0.7993	0.19		
	8	5.5083	5.5083	1	0.7935	0.19		
	9	7.054	7.054	1	0.5327	0.19		
	10	9.6351	9.6351	1	0.5327	0.19		

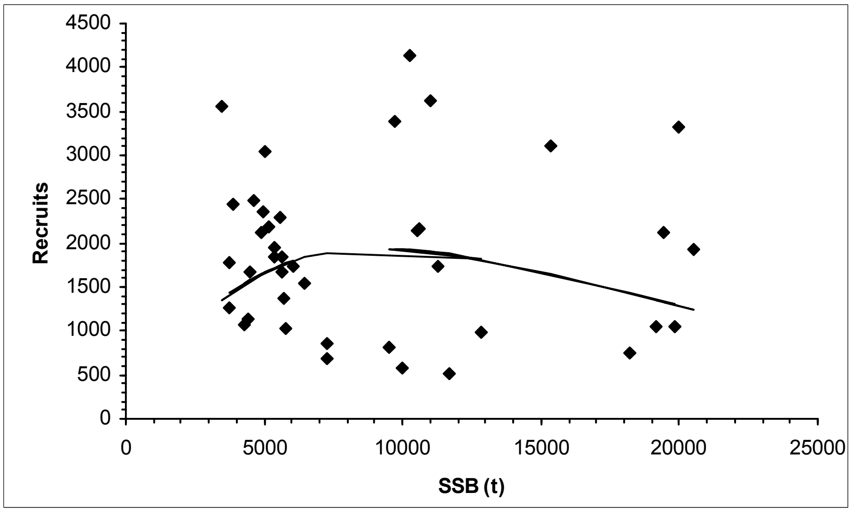


Fig. 4.2.10.1.2. Turbot in the Black Sea from XSA using IUU estimates. Spawning stock - recruitment relationship expressed as the Ricker function.

Table 4.2.10.1.2. Turbot in the Black Sea from XSA using IUU estimates. Input parameters to the production model.

age min	age group	stock weight	catch weight	maturity	F	M	R=a*SSB*exp(-SSB/k)	
1	1	0.3272	0.3272	0	0.0039	0.19	a=	1.15
age max	2	0.7737	0.7737	0	0.0465	0.19	k=	15.41
10	3	1.327	1.327	0.45	0.1060	0.19	sterror=	0.30729547
Fref	4	1.8616	1.8616	0.7	0.2908	0.19		
0.5125	5	2.4481	2.4481	0.95	0.3262	0.19		
	6	3.1938	3.1938	1	0.3515	0.19		
	7	4.2219	4.2219	1	0.7832	0.19		
	8	5.5083	5.5083	1	0.8110	0.19		
	9	7.054	7.054	1	0.5001	0.19		
	10	9.6351	9.6351	1	0.5001	0.19		

4.2.10.3 Results

Relations between yields and fishing mortalitis (F 4-8) from XSA using official landings and IUU estimates are presented in Fig. 4.2.10.3.1 and Fig. 4.2.10.3.2.

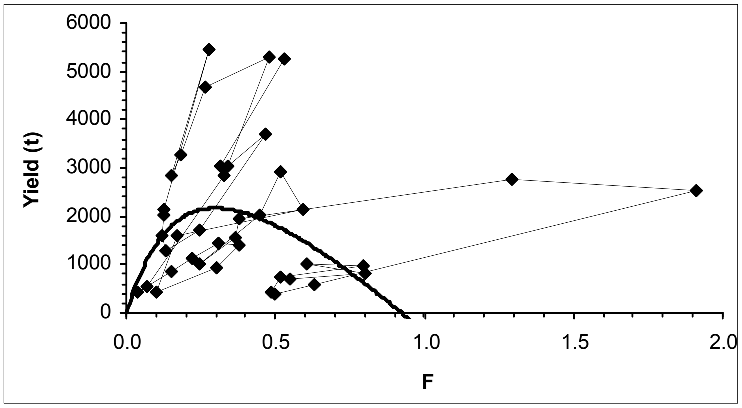


Fig. 4.2.10.3.1 Turbot in the Black Sea from XSA using official landings. Relation between yield and fishing mortality (F 4-8) observed (linked dots) and its estimated sustainable levels.

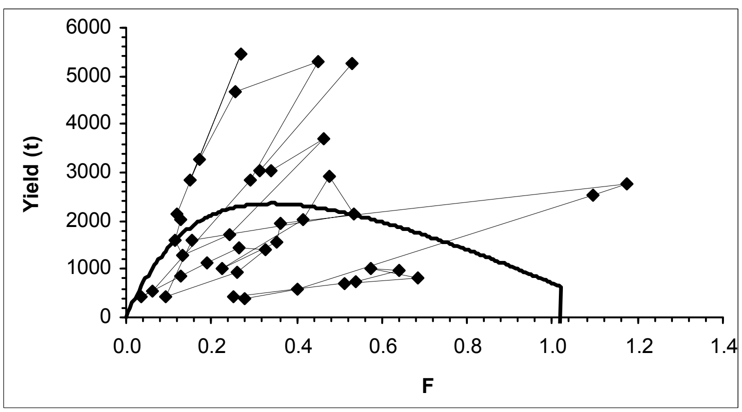


Fig. 4.2.10.3.1Turbot in the Black Sea from XSA using IUU estimates. Relation between yield and fishing mortality (F 4-8) observed (linked dots) and its estimated sustainable levels.

Results of estimation of reference points based on equilibrium models are given in Table 4.2.10.3.1. The reference points from the two assessments are very close. The WG proposes $F_{0.1} = 0.15$ as an upper limit of exploitation (as a proxy of Fmsy).

Table 4.2.10.3.1. Reference points estimated based on equilibrium models with inputs of official landings and IUU estimates

Reference point	Assessment based on official landings	Assessment based on IUU estimates
Fmax	0.302	0.307
Fmsy	0.308	0.348
F0.1	0.154	0.16
Bmsy	9516 t	9611 t
MSY	2273 t	2457 t

4.2.11 Data quality

The available data from both fisheries dependent and fisheries independent sources is considered good enough in order to perform a reliable assessment of the stock. However, the lack of data for previous years and the unknown share of unreported landings make the analysis very sensitive to different options.

Landings from 2009 by age and size groups were not submitted by the Bulgarian authorities.

4.2.12 Scientific advice

4.2.12.1 Short term considerations

State of the spawning stock size: Uncertainties regarding the actual catch forces the WG to interpret the assessment results only in relative terms, i.e. they are considered indicative of trends only. In the absence of reference points the WG cannot fully evaluate the state of the SSB. However, current biomass of turbot is much lower compared to historical levels. The drop in abundance is consistent with the decreases in CPUE and landings.

The index of stock abundance from surveys shows variability throughout the time series, but no trend is observed.

State of recruitment: Recruitment has increased since 2003 but this has not yet materialized in a significant increase in SSB.

State of exploitation: As the estimates of fishing mortality are interpreted as relative changes only, the WG is unable to fully evaluate the stock status versus the limit proposes reference point F=0.15. Fishing mortality has peeked in 2000-2001and remains quite high since then: F = 0.6 – 0.8. Despite the recently low TACs the fishing mortality remains at a level certainly higher than the proposed reference point with no signal of reduction.

4.2.12.2 Medium term considerations

Currently precautionary reference points are not applied. STECF SG Black Sea-10-01, proposes $F_{0.1}$=0.15 as limit reference point (Fmsy proxy) of exploitation.

In line with previous advice, the WG reiterates that the exploitation of turbot in the Black Sea should be kept at the lowest possible level in order to allow the stock to recover.

4.3 Anchochy in the Black Sea

4.3.1 Distribution area, conditions and migration routes

Two populations of anchovy *(Engraulis encrasicolus)* exist in the Black Sea: the Black Sea and the Azov Sea stocks (Ivanov and Beverton 1985). The later reproduces and feeds in the Azov Sea and hibernates along the northern Caucasian and Crimean coast of the Black Sea. The Black Sea stock has higher ecological and commercial importance and the information bellow concerns only this stock which will be further called Black sea anchovy.

Black sea anchovy is distributed in the whole Black Sea – Fig. 4.3.1.1. In October-November it migrates to the wintering grounds along the Anatolian and Caucasian coasts in southern Black Sea. In these areas it forms dense wintering concentrations in November-March which are subject to intensive commercial fishery. In the rest of the year it occupies its usual spawning and feeding habitats across the sea with some preference to the shelf areas and the northwestern part of the sea– characterized by the largest shelf area and high productivity due to abundant river run-off (Faschuk *et al*. 1995, Daskalov, 1999).

Anchovy first spawns at age of about 1 year. It spawns during the summer, which is also the main feeding and growth season. The main feature characterizing the summer habitat is the strong stratification of the water due to the seasonal thermocline and reinforced in coastal and shelf waters by the river plumes. Anchovy was found to spawn mainly in the surface layer of these warm and stratified areas (Arkhipov, 1993; Fashchuk *et al.* 1995). Eggs and larvae are retained in the coastal layer stabilized in depth by the thermocline and protected from the offshore by thermo-haline fronts. A large convergence zone is formed on the northwestern and the western shelf (the main anchovy spawning area) due to the river Danube inflow, which favors fish offspring retention (Radu and Maximov 2006-2008).

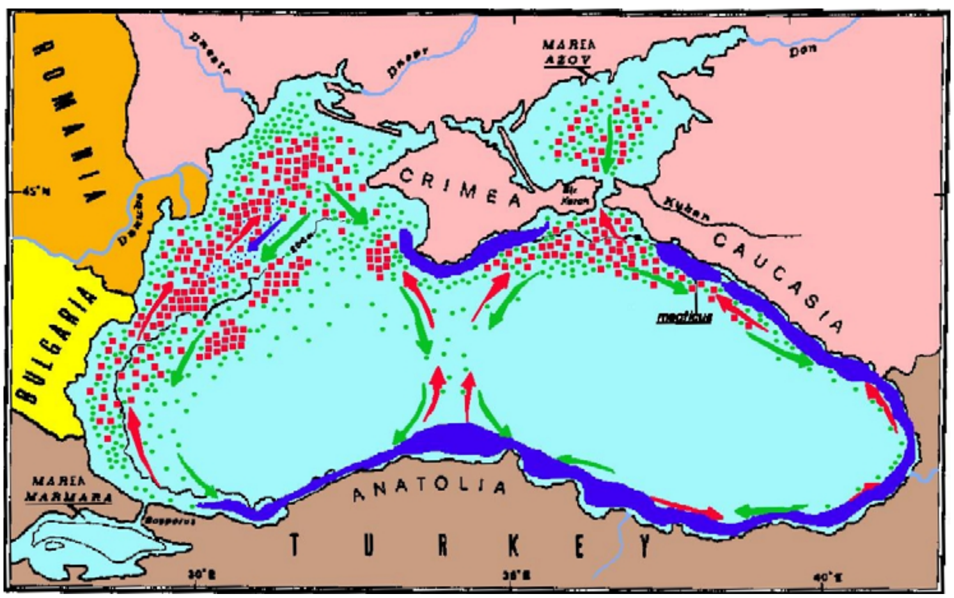


Fig. 4.3.1.1. Distribution of the anchovy at the Romanian littoral and in the whole Black Sea

4.3.2 The evolution of the main anchovy catches

Anchovy is an object of both artisanal (with coastal trap nets and beach seines), and commercial purse-seines fishery on the wintering grounds.

The catch of the Black Sea countries increased until 1985-1986 after which a sharp decline occurred. For instance, the Turkish catch of anchovy in 1990-1991 fell to 13-15% of the 1985-1986 level. On the Northwest Shelf the anchovy catch declined at least tenfold, and after 1989, anchovy fishing ceased in the Azov Sea.

During the 1990/1991 fishing season an unprecedented situation arose: no fishable aggregations were found off Georgia and the catch was only 2.3 thousand tons.

Fishing situation off Anatolian coast was also extremely bad: Turkish catches were 73 thousand tons in the 1990/1991 comparable to the level of the early 1970s when the fishing power was much less.
Heavy fishing on small pelagic fish predominantly by the Soviet Union, and later also by Turkey, was carried out in a competitive framework without any agreement between the countries on limits to fishing. Depletion of the small pelagic stock appears to have led to increased opportunities for population explosion of planktonic predators (jelly fish and ctenophores) which have competed for food with fish, and preyed on their eggs and larvae.
The dramatic depletion of Black Sea catches after 1989, in fact the depletion of fish stocks, were produced by the severe degradation of environmental conditions, at which there were added the overwhelming developments of the exotic species ctenophore *Mnemiopsis leidyi* after 1980, as well as the overexploitation of resources (Daskalov et al. 2008) .
The total anchovy catch was progressively increasing since 1980 to 1988 – Fig. 4.3.2.1, when maximum yield was obtained (606,401t) then decreasing up to a minimum of 102,904 t in 1990 (excepting 1988), 90% from this quantity being obtained by Turkey.
In spite of improving the fishing effort by the continuous increase of fishing vessels number, at the end of the 1980's when the outbreak of the alien jellyfish occurred, catches dramatically declined up to three times.
The state of the anchovy stock has improved after the collapse in 1990s, and in 2000-2005 the catches reached levels of about 300 th. tons.

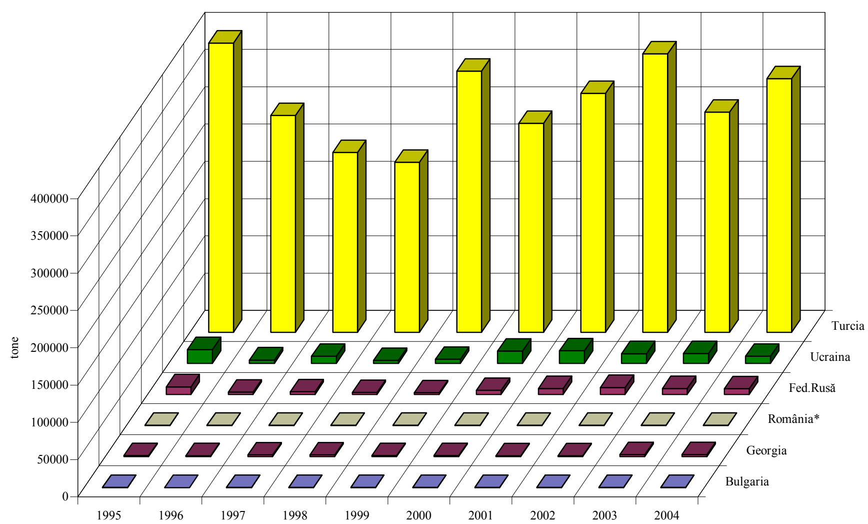


Fig. 4.3.2.1. The anchovy catches in the Black Sea

However in 2006 the anchovy catches dropped to 119 thousand t in Turkey (M. Zengin, personal communication) showing that the stock is not in a good condition. The possible causes of the drop ranges from climate effects (raised water temperature may cause a dispersal of fish schools making them less accessible to the fishing gears), abundant predators (bonito) or overfishing. In 2006 the catch increased again to 212 thousand t.

4.3.3 Biologic parameters of the anchovy

In the last years, the anchovy individuals presented a total length which ranged between 106.14 mm and 115.88mm and the average weight of 6.79 -9.56g. The age of individuals oscillated between $0;0^+$ - $3;3^+$, dominant being the groups 1; 1^+ - 2; 2^+, as a consequence of the high fishing pressure in the wintering area (Maximov et. al, 2008).

4.3.4 The state of the anchovy stock biomass

The stock has been monitored by egg, larvae, and juvenile surveys; adult stock surveys using pelagic trawl and hydroacoustics, and the Spawning Stock Biomass (SSB) has been a subject of experimental assessments using the "egg production method" in the USSR, Bulgarian and Romanian waters (main reproductive area) in 1987-1991 (Arkhipov *et al*., 1991). Total biomass in the Black Sea until 1993 has been assessed based on catch-at-age data using VPA and the modified Baranov method (Prodanov *et al*. 1997). Recent trend in anchovy SSB was estimated using a linear regression between logarithmically transformed SSB and CPUE data of the Turkish purse seine fleet (Daskalov *et al*. 2008). An approximate fishing mortality after 1993 was estimated as a ratio between the landings and SSB.
Sharp reductions in biomass and catch in the early 1990s can be described as a stock collapse.
Simonov *et al*. (1992) and Panov and Spiridonova (1998) have found that anchovy abundance and aggregating behavior depend on hydro climate and used some climate indices like SST at Batumi and atmospheric circulation to draw relationships with the anchovy stock.

4.3.5 Protection measures for anchovy

The lack of an adequate management in the Black Sea fisheries is also underlined by the fact that in spite of the obvious decline of stocks, the fishing effort continued to increase.

The development and enforcement of national legislative and regulatory measures played a significant role in improving the current state of the fish stocks and control over responsible fisheries in the region. The basic legislation concerning fisheries that was adopted before 1996 in the Black Sea coastal states, was further developed, improved and enforced over a period of five years. They directly addressed the conservation issues. Only in Turkey the basic laws of 1971 and 1986 still remain unchanged though currently the Turkish Parliament is considering the new Law on Fisheries. The current fisheries legislation is sufficient to sustain and manage the marine fish and other living resources in all Black Sea states. In the transboundary context, it still requires strengthening and regional harmonization of the regulatory and legal framework especially in regard to the conservation and protection of the fish and other living marine resources (BSC Reports).

Also, given the strong natural variability, transboundary migratory behavior, and sensitivity to various environmental impacts the protection and sustainable use the anchovy resource can be achieved only by coordinated international management and regulation based on sound scientifically grounded stock assessment.

4.3.6 Availability of data for the assessment

STECF SG Black Sea-10-01 found out that data available in different national databases would allow performing a quantitative assessment of this stock – Table 4.3.6.1 and Table 4.3.6.2. This however would be less straightforward than previous assessment of sprat because of the specific seasonal and migration behaviour of anchovy: 95% of the catch is realised in Turkish waters (southern Black Sea) in the autumn and winter. For this reason data from the Turkish fisheries is of utmost importance. It can be complemented by biological (age and individual size and growth) and survey information (acoustics, juveniles, egg-production) from Bulgaria, Romania and Ukraine.

At the first stage data must be carefully screened and organised into age structured matrices. Age structured assessment methods such as ICA and VPA (XSA) than can be applied similar to sprat.

Table 4.3.6.1. Data availability by countries.

Type of data	BG	RO	UKR	TR	Selection for Assessment	Coments
Official landings	1925-2008	1950-2008	1967 - 2009	1967 - 2008 (after 15th July)		
Illegal, Unreported Catch	no	no	no	no		
Fishing effort and CPUE	no	1980-2008	till 2009	1998, 2000-2008		* to be reviewed
Number of fishing vessels			till 2009	1993-2008		
Research surveys -adult			till 2009	1993-1998, 2000-2008		
Reserch surveys -juvenile		1995-2008	till 1992	no		
Hydroacoustic surveys	1984-87, 1990		1992, 1998-2003	1990-1993		
Length composition	1998-2000	1980-2008	till 2008	till 2008		
Weight at length (survey, landings)	1998-2000, *VII, VIII, IX, XI.1999	1980-2008	till 2009	till 2008		
Age composition	1995-2000, VII, VIII, IX, XI.1999	1980-2008	till 2009	till 2008		
Weight at age (survey, landings)	1995-2000	1980-2008	till 2009	till 2008		
Maturity at age		1980-2008	till 2008	?		
Natural mortality		1980-2008	till 1990	till 2008		

Table 4.3.6.2. Anchovy landings by countries (FAO Fisheries Statistics, GFCM Capture Production 1970 – 2006, 2007 – 2009 from National Fisheries Statistics of countries).

Year	Bulgaria	Georgia	Romania	Russian Federation	Turkey	Ukraine	Un. Sov. Soc. Rep.
1970	90	.	2261	.	71506	.	117800
1971	126	.	3791	.	70400	.	126700
1972	156	.	3200	.	91675	.	111000
1973	264	.	1400	.	86998	.	132500
1974	41	.	855	.	75728	.	227900
1975	15	.	592	.	59142	.	173626
1976	72	.	2749	.	67992	.	236234
1977	113	.	1646	.	71366	.	152607
1978	37	.	2746	.	105184	.	134855
1979	307	.	2251	.	133678	.	126763
1980	209	.	6431	.	239289	.	165900
1981	70	.	4942	.	259767	.	153272
1982	266	.	4294	.	266523	.	175100
1983	784	.	5532	.	289860	.	200630
1984	239	.	6354	.	318917	.	240640
1985	92	.	2414	.	273274	.	110200
1986	96	.	2510	.	274740	.	191370
1987	13	.	1447	.	295902	.	66241
1988	115	97452	3171	64852	295000	65872	-
1989	.	32401	61	16426	96806	15536	-
1990	.	4656	5	6780	66409	17392	-
1991	.	5643	46	42	79225	1796	-
1992	.	6871	85	7294	155417	11507	-
1993	.	1656	374	2137	218866	8698	-
1994	.	857	197	4600	278667	14500	-
1995	35	1301	189	10071	373782	15516	-
1996	23	1232	138	2954	273239	2898	-
1997	44	2288	45	3283	213780	7695	-
1998	48	2346	146	2465	195996	3367	-
1999	36	1264	155	2268	310801	5188	-
2000	64	1487	204	5292	260670	11720	-
2001	102	941	186	7766	288616	11953	-
2002	237	927	296	9271	336419	10450	-
2003	131	2665	160	7999	266069	12169	-
2004	88	2562	135	7323	306656	5947	-
2005	14	2600	154	6706	119255	6380	-
2006	6.464	9222	11	3925	212081	7090	-
2007	60.44	17447	35	4900	357089	4573	
2008	27.666	25938	15	9500	225334	4298	
2009	42.41		21	9927	185606	8024	

4.4 Mediterranean horse mackerel

4.4.1 Distribution areas and migration routes

The Black sea horse mackerel is a subspecies of the Mediterranean horse mackerel *Trachurus mediterraneus.* Although in the past the Black sea horse mackerel has been attributed to various subpopulations, in a more recent study Prodanov *et al.* (1997) brought evidence that the horse mackerel rather exists as a single population in the Black sea, and thus all Black sea horse mackerel fished across the region should be treated as an unit stock. Biometric indices were insufficient to distinguish two *horse mackerel* subpopulations in the Black Sea (Yankova & Raykov, 2006). The same authors concluded that all of the morphological differences are possible due to variability of the habitat and sample size of the study.
The horse mackerel is migratory species distributed in the whole Black Sea (Ivanov and Beverton, 1985, Fig. 4.4.1.1). In the spring it migrates to the north for reproduction and feeding. In summer the horse mackerel is distributed preferably in the shelf waters above the seasonal thermocline. In the autumn it migrates towards the withering grounds along the Anatolian and Caucasian coasts migration (Ivanov and Beverton, 1985). The horse mackerel population in the Black Sea mainly winters along the Crimean, Caucasian and Anatolian coasts and warm sections of the Marmara Sea. They winter at a depth ranging between 20 and 90 meters off Crimea and between 20 and 60 meters off the Caucasian coasts. The horse mackerel population continuously remains in the eastern Black Sea winters in an area north-east of Trabzon. The population migrating between Marmara and the eastern Black Sea spend the winter in the Bosphorus area and off the Marmara Sea at optimal depths ranging between 30 and 50 meters. Depending on water temperature, feeding migration starts in mid-April or towards the end of that month (Demir, 1958). Horse mackerel groups migrate from the Bosphorus to the Bulgarian and Romanian coasts in the north. They are also believed to migrate from Crimea to the north-west and from the Caucasian and north-eastern Anatolian coasts to the Crimean coasts. Autumn migration starts in September and reaches a peak in October and November (Ivanov and Beverton, 1985). No major study on the horse mackerel biomass wintering off Anatolian coasts was undertaken in the past decade. In a study conducted by Bingel et al. (1996) early in the 1990s, Shaefer's "Residue Yield Model (MSY) as employed, and the optimum amount of catch was estimated at 80,000 tons. Compared with the amount of catch taken to ground in the subsequent years, however, the amount of maximum lasting yield never reached the amount estimated in those years, and rather remained much below that level.

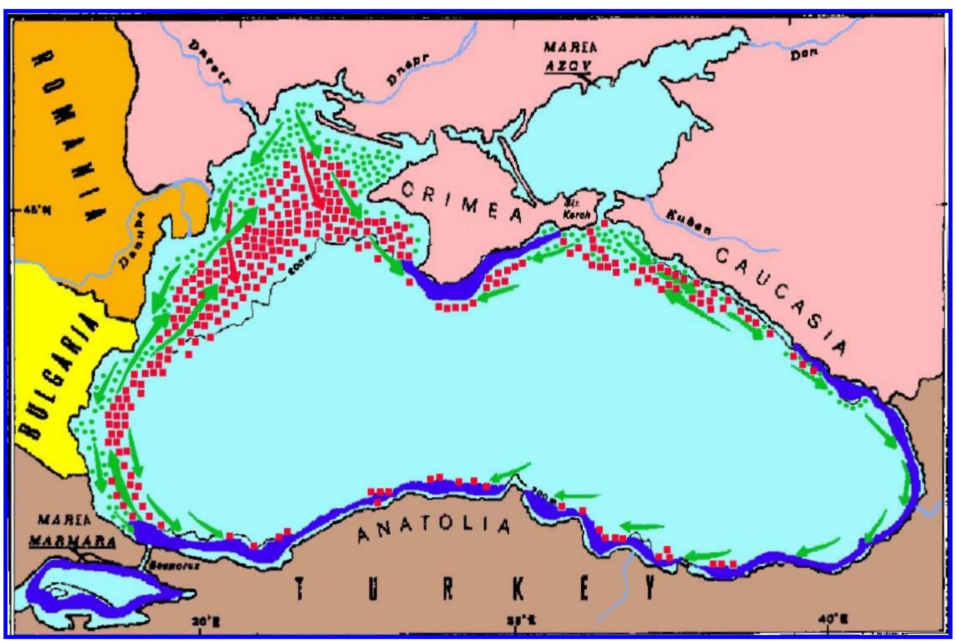


Fig.4.4.1.1. Distribution and migration routes of horse mackerel in the Black Sea.

The horse mackerel matures at age of 1-2 years during the summer, which is also the main feeding and growth season. It spawns in the upper layers, mainly in the open part of the sea as well as near the coast (Arkhipov, 1993). Eggs and larvae are often found in areas with a low productivity and higher salinity (Arkhipov, 1993). Daskalov (1999) has found that horse mackerel recruitment is related to divergence and increased productivity of the sea.

4.4.2 State of the fisheries and stocks

The horse mackerel (*Trachurus mediterraneus*) fishery operates mainly on the wintering grounds in the southern Black Sea using purse seine and mid-water trawls. The horse mackerel of age 1-3 years generally prevails in the commercial catches, but strong year classes (for example, the 1969-year class) may enter into exploitation at age of 0.5 year and may prevail up to age 5-6 years. Over the last 40 years, highest horse mackerel catches were reported in the years preceding *M. leidyi* outbreak (1988-1990). (Prodanov *et al*., 1997; FAO, 2007). The maximum catch of 141 thousand tons was recorded in 1985, from which ~100 thousand tons were caught by Turkey (Prodanov *et al*., 1997). In the next four years catches remained at the level of 97-105 thousand tons. In the period 1971-1989, the stock increased, although years of high abundance alternated with years of low abundance due to year class's fluctuations, typical of this fish. VPA estimates showed that the stock was highest in 1984-1988 (Prodanov *et al*., 1997). Scientists (Chashchin, 1998) believed that the intensive fishing in Turkish waters in 1985-1989 has led to overfishing of horse mackerel population and reduction of the stock and catches in the next years. A drastic decline in stock abundance occurred after 1990 when the stock diminished by 56%. In 1991 the horse mackerel stock dropped to a minimum of 75 thousand tons and the catch dropped to 4.7 thousand tons that is a twenty fold reduction compared to the average annual catch in 1985-1989. In contrast to anchovy and sprat, the horse mackerel stock still remains in a depressed state. There was no fishing for horse mackerel by the former USSR countries in 1992-1998 because no fishable aggregations were found on the wintering grounds. Small quantities of horse mackerel were caught with trap-nets in the coastal areas of the Crimea and Caucasus. In Turkish waters, horse mackerel catches in 1994-2006 were 9-11 thousand tons, i.e. at the level of the years 1950-1975 before the start of industrial fishing.

The horse mackerel recruitment has been highly variable with the stock biomass supported by sporadic strong year-classes (e.g. 1969, 1983, 1987) followed by weak-ones. Thus, the influence of a strong year-class can be traced through the subsequent few years of biomass increase. No evidence of reliable stock-recruitment relationship has been found (Daskalov, 1999). The relationships with selected environmental variables has been explored by Daskalov (1999, 2003). A strong negative correlation was with surface temperature (SST) has been found. It may appear surprising for a warm-water summer spawning species to correlate negatively with SST. Such relationships have been also found however in other studies (Simonov et al., 1992). The effect of the wind stress was significant and generally positive. These results indicate that horse mackerel recruitment has been more abundant in years with increased physical forcing and enrichment, probably related to the spawning distribution wide spread over areas of low productivity.

During 1985-1993, only in 1988 a relatively successful recruitment was recorded. Despite of its coincidence with the first year of *M. leidyi* outbreak, the juveniles from this cohort were sufficiently well supplied with food. As the first burst of *M. leidyi* occurred in the autumn of 1988, the summer zooplankton maximum production did not suffer much from the devastating effect of *M. leidyi*. The copepods *Oithona nana* and *Oithona similis*, constituting the main food of larval horse mackerel (Revina, 1964), were especially abundant. However, the favorable trophic conditions for larvae in summer 1988 failed to ensure the formation of numerically strong year-class because further in the year juveniles were faced with strong feeding competition with *M. leidyi*. Sharp decline in *Oithona* under the predation pressure of *M. leidyi* in the subsequent years (Vinogradov *et al*., 1993 ;) affected the survival of horse mackerel. Dietary studies of juvenile and adult horse mackerel (Revina, 1964) have shown that both the habitat diet of juvenile horse mackerel and *M. leidyi* overlap, therefore the strong feeding pressure by *M. leidyi* on zooplankton directly affected larval and juvenile horse mackerel. Food in relation to fish size shows that the most important for the diet of horse mackerel groups are *Mysidacea* and *Pisces.* The contribution of the rest of groups was relatively low (Yankova & Raykov, 2008). The same authors reveal that main prey of the Black Sea horse mackerel is fish and zooplankton. This group represents over 55% of the total IRI and was the main food for this species. Besides having the largest number of zooplankton, it had a high impact on populations of commercial fish such as sprat and anchovy.

Over the last 40 years, highest horse mackerel catches were reported in the years preceding *M. leidyi* outbreak (1988-1990). Quantitative stock assessments showed that the stock was highest in 1984-1988, although years of high abundance alternated with years of low abundance due to year classes' fluctuations, typical of this species. Scientists believed that the intensive fishing in Turkish waters in 1985-1989 has led to over fishing of horse mackerel population and reduction of the stock and catches in the next years. A drastic decline in the stock abundance occurred after 1990 when the stock diminished by 56%. In 1991 the horse mackerel stock dropped to a minimum of 75 thousand tons and the catch dropped to 4.7 thousand tons, hat is a twenty fold reduction compared to the average annual catch in 1985-1989. In contrast to anchovy and sprat, the horse mackerel stock still remains in a depressed state. The total catch (taken predominantly by Turkey) in 2000-2005, remains ~10 th. t, similar to the pre-industrial period 1950-1975.

State of the fisheries in Turkey

Horse mackerel stock was a subject of overfishing, resulting in a fisheries collapse in the beginning of 1990's (Ozekinei et al., 2001). The ratios of undersized individuals for horse mackerel were 89% and 92% for autumn and winter seasons, respectively. The corresponding ratios for the horse mackerel for the same seasons were 70 and 67%, respectively. Minimum allowable sizes for horse mackerel and bluefish are 13 and 20cm, respectively. The 50% cumulative values obtained trawling trials are close to those figures. But the ratios of the undersize fish of horse mackerel (< 13 cm) for the seasons of spring, autumn and winter were calculated as 93.7, 75.8 and 30.7%, respectively (Dincer et al., 2007).

Production of the horse mackerel, which is the second most important pelagic catch along Turkey's Black Sea coasts after the European anchovy, steadily increased until the mid-1980s and reached its maximum level of approximately 100,000 tons in 1985. The total amount of catch, however, constantly declined due to uncontrolled fishing activities and over-fishing in the 1990s and declined to 80,000 tons. Research into commercial fish stocks on Turkey's Black Sea coasts conducted during the second half of the 1980s indicated that the horse mackerel population suffered the greatest fall in terms of quantity after the sea-perch among the pelagic stocks in the past 15 years (Bingel et al., 1995; Zengin et al., 1998a; Zengin, 2001). The breakdown of horse mackerel caught by commercial fishermen between 1991 and 1993, when the amount of horse mackerel catch started to decrease along Turkish coasts, by length confirms this conclusion. The average lengths of horse mackerel caught by large purse-seine nets and trawlers during those years were 11.1 cm, 10.9 cm and 10.6 cm, respectively (Zengin, 1998). Average operating ratio (E) calculated for the same period was 0.78 (Genc et al., 1999), which clearly demonstrates the over-fishing of the horse mackerel stock. This sharp fall in the horse mackerel catch steadily increased until the end of the 1990s. The share of horse mackerel below optimal catch length (L_{opt}.= 13 cm) in the total catch caught by coastal surrounding nets in the eastern Black Sea early in the 1990s (1990-1993) was 52.2%, rose towards the end of 1990s (66.7 %) (Zengin et al., 1998a, Zengin et al., 2002) – Table 4.4.2.1. The length of the horse mackerel population off the southern Black Sea coast after they reach initial reproductive maturity is 11.7 cm (Genc et al., 1999). A large part of immature and young individuals below the optimal catch length (*discards catch*) are taken by coastal fishermen from stock and sold on the market under the counter or destroyed on the sea. In order to eliminate this trend, which is an indicator of growth over-fishing, new fishing methods and management planning are also considered necessary for horse mackerel populations.

After the beginning of the 2000s the landings started to increased again. Total Turkish Black sea catch was up to 26.000 tons (2006 official statistics) and the average length also increased 13.7 cm. (Genç et al, 2006).

Horse mackerel stocks in the Black Sea are usually caught by Turkish fishermen by using active (bottom trawler, pelagic trawler and large bag-shaped nets) and passive (extension and longline) nets Table 4.4.2.2. Almost the whole horse mackerel catch (98.2%) is caught by large bag-shaped nets. CPUE of fishing boats using that type of net for catching horse mackerel is 3837.5 (600-10,000) kg/boat/day (Zengin et al., 2003). The remaining part of the catch is caught by bottom trawler, pelagic trawler, extension net and long lines. A large part of the catch (80%) is caught in the autumn and the first part of winter (September-December) (Zengin et al., 1998a) (Fig. 4.4.2.1.).

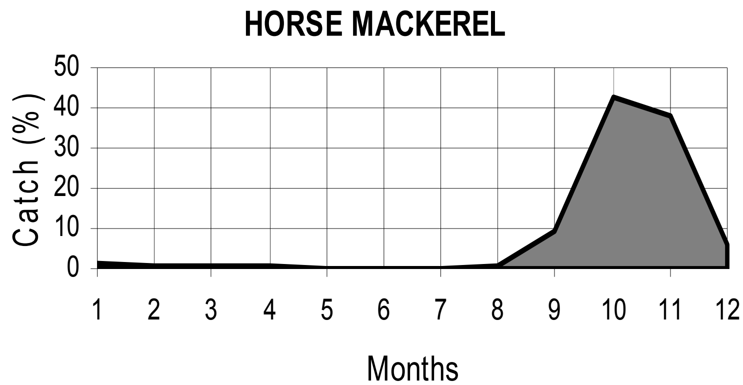


Figure 4.4.2.1. Catch distribution of the Horse mackerel in the south Black Sea by monthly

Table 4.4.2.1. Distribution of average length (cm) and catches below the optimum catch length (L_{opt}) in the southern Black Sea in the period between 1990 and 2007.

Fishing season	Landings (tons)	Optimum catch length (cm)
1990	75882	11.1
1991	25679	10.9
1992	20989	10.1
1993	23945	-
1994	25275	-
1995	15809	-
1996	16093	-
1997	11097	-
1998	8246	-
1999	8331	-
2000	16181	12.4
2001	16750	-
2002	8903	-
2003	9213	-
2004	9113	13.1
2005	17003	13.7
2006	25927	13.1
2007	17429	12.8

Table 4.4.2.2. % catch and catch per unit effort according to type of net in the south Black Sea in the period of between 1990 and 2000

Fish species	Parameters	Purse seine	Trawl	Pelagic trawl	Gill-nets	Set-net	Long-line
Horse mackerel	%Catch CPUE (kg/boat/day)	98.2 3837.5 (600-10000)	0.3 -	0.4 2038.7 (95.9-79.20)	0.9 -	-	0.2 -

4.4.3 Availability of Data for assessment

STECF SG Black Sea-10-01 found out that data available in different national databases would allow performing a quantitative assessment of this stock. Data from the Turkish fisheries (~95% of the catch) will be very important but horse mackerel fisheries are quite important for rest of the Black Sea countries especially when the stock is high that assures a regular strong migration in the northern Black Sea. Fisheries and biological (age and individual size and growth) and survey data (acoustics, juveniles, egg-production) from all countries need to be thoroughly compiled.

At the first stage data must be carefully screened and organised into age structured matrices. Age structured assessment methods such as VPA (XSA) and ICA than can be applied similar to sprat and turbot.
STECF SG Black Sea-10-01 collates the following metadata available in different national databases – Table 4.4.3.1. and landings statistics – Table 4.4.3.2.

Table 4.4.3.1. Data availability by country.

Type of data	TURKEY	ROMANIA	BULGARIA	UKRAINE	Comment
Catch (monthly,quarterly,yearly)	Yes	Yes, Monthly, 2006-08	The end year 2008	The end year 2009	
IUU catches	Only can be estimated	no	The end year 2008	no	Expert est.: low level (not more then 10-15%)
Fishing gears	Yes	yes	The end year 2008	The end year 2009	Trawls (by-catch), Lift cone-shaped nets with electric light attraction, Pound nets
Fishing seasons	Yes	yes	The end year 2008	The end year 2009	Trawls: November-March; Lift cone-shaped nets:December-February; Pound nets: June-September
Fishing areas	Yes	yes	The end year 2008	The end year 2009	Trawls&Lift cone-shaped nets:Crimean waters; Pound nets: Crimean&NW of Black Sea coastal waters, Crimean of Azov Sea coastal waters
Fishing and natural mortality estimations	Yes	yes	no	no after 1992	
Mean individual weights	Yes	yes	The end year 2008	The end year 2009	2003-2008
Catch-at-age	Yes	yes		The end year 2009	

Type of data	TURKEY	ROMANIA	BULGARIA	UKRAINE	Comment
Length and weight at age	Yes	yes	yes	The end year 2009	
CPUE from commercial yield and surveys	Indirectly		no	2000-2006	
Migration routes (spawning,fattening, wintering grounds)	Indirectly…	yes	yes	The end year 2009	
Existing fishery regulations in country	Yes	yes	yes	The end year 2009	
Existing analyses for 1950-2009	Some years; 1990-93	yes	yes	no after 1992	In Turkey; they are some poulation parametrs diffrent yeras, diffrent area and institutions

Table 4.4.3.2. Horse mackerel landings by countries (FAO Fisheries Statistics, GFCM Capture Production 1970 – 2006, 2007 – 2009 from National Fisheries Statistics of countries).

Year	Bulgaria	Georgia	Romania	Russian Federation	Turkey	Ukraine	Un. Sov. Soc. Rep.
1970	689	…	2532	…	16500	…	700
1971	631	…	2225	…	7300	…	4400
1972	534	…	500	…	14200	…	22100
1973	849	…	600	…	18400	…	10800
1974	2169	…	608	…	12143	…	3000
1975	1973	…	1003	…	12980	…	4330
1976	1809	…	1514	…	14078	…	18329
1977	791	…	404	…	14674	…	4712
1978	565	…	729	…	23529	…	629
1979	935	…	1179	…	59772	…	737
1980	820	…	1536	…	42339	…	592
1981	476	…	588	…	40543	…	345
1982	384	…	291	…	48918	…	1862
1983	497	…	1510	…	54548	…	7257
1984	1016	…	872	…	69980	…	5278
1985	756	…	1035	…	100417	…	35252
1986	871	…	945	…	100943	…	1610
1987	826	…	997	…	90850	…	3543
1988	1677	32	2666	91	93006	275	
1989	1101	19	1459	30	94023	255	
1990	164	25	165	5	75882	28	
1991	232	2	48	2	25679	2	
1992	82		22		20989		
1993	79		30		23945		
1994	80		35	1	25275	1	
1995	70		23	1	15809	2	
1996	68		13		16093		
1997	36	18	1		11097	5	
1998	40	13	15	2	8246		
1999	30		3	2	8331	1	
2000	111	35	8	2	16181		
2001	130	7	17	6	16750	1	
2002	142	19	21	28	8903	34	
2003	142	70	10	77	9213	745	
2004	74	56	15	105	9113	272	
2005	29	60	12	169	17003	329	
2006	62.834	55	8	200,5	25927	476	
2007	115.88	53	6	63,2	17429	211	
2008	179.607	8	11	154,24	20124	366	
2009	176.91		17	124,04	8977	260	

4.5 Whiting in the Black Sea

4.5.1 Distribution area, conditions and migration routes

In the Black Sea, the whiting (*Merlangius merlangus*) is one of the most abundant species among the demersal fishes. It does not undertake distant migrations, spawning mainly in the cold season within the whole habitat area – Fig. 4.5.1.1. The whiting produces pelagic juveniles, which inhabit the upper 10-meter water layer for about a year. The adult whiting is cold-living, preferring temperatures 6-10º C. Fishes at the age less than 6 years are predominant in the whiting populations, the older year classes are found in catches individually. It occurs all along the shelf, dense commercial concentrations are formed by 1-3 year old fishes in the water down to 150 m depth, most often at 60-120 m depths. Such concentrations on the shelf of Bulgaria, Georgia, Romania, the Russian Federation and Ukraine not do from every year, appearing at periods of 4-6 years - in the years of appearance of highly productive year classes. In these countries, whiting is very rarely the target species for fisheries and yielded as by-catch during trawl fisheries for other fish species or while non-selective fisheries with fixed nets in the coastal sea areas.

In the vicinity of the southern coast of the Black Sea whiting concentrations are more stable. Turkey is the only country in the region, where the annual target trawling fisheries for this fish is conducted.

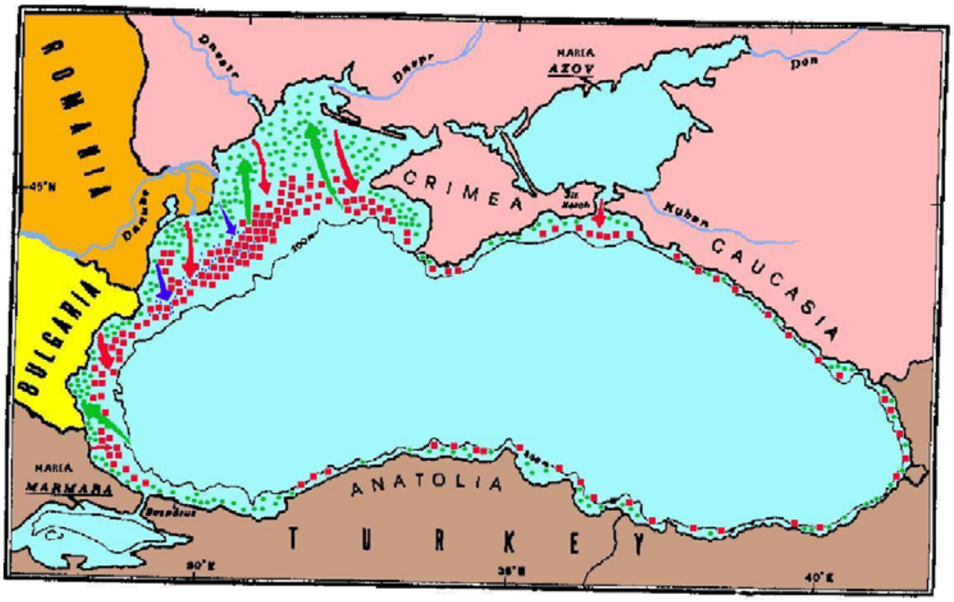


Fig.4.5.1.1. Map of distribution of whiting in the Black Sea.

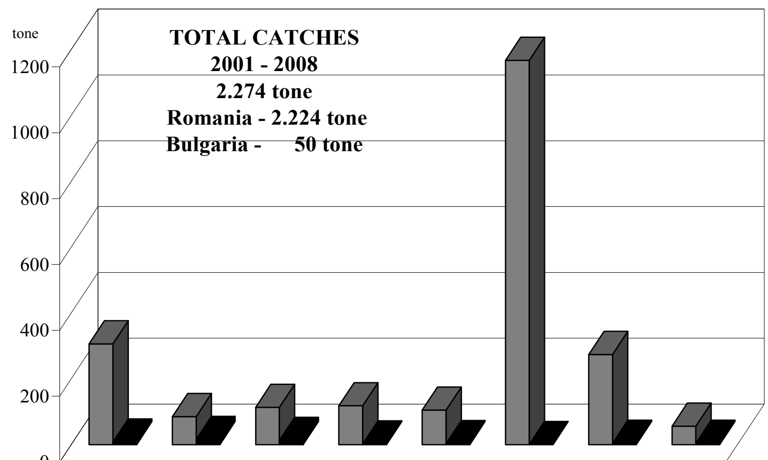
4.5.2 The evolution of the main whiting catches

Official statistics in all Black Sea countries does not reflect the true capture of whiting which is much higher than reported one.

In 1996 – 2005 the total mean annual catch of whiting by Black Sea countries (except Turkey) according to the data of official statistics submitted to FAO was less than 0.6 thousand tons. It should be noted that with target trawl fisheries for sprat and other fishes whiting is by-caught in larger quantities that it is specified in official reports of the countries. Thus in the waters of Ukraine during sprat fisheries with midwinter trawls in 1996 – 2002 whiting by-catch was assessed in the range of 0.65 – 1.8 thousand tons (Shlyakhov, Charova, 2003). Sprat catches with by-catches of small whiting are almost not graded to size and they are recorded in statistics as sprat. Grading is made in case of increased by-catches (more than 10-20%), graded whiting both landed under its name during discharging, or merely discarded (although it is prohibited by the Regulations of Fisheries). The same situation takes place in the waters of Bulgaria, Georgia, Romania and the Russian Federation.

Turkey is the only country in the region, where the annual target trawling fisheries for this fish is conducted. Trawling is permitted only in the season between September and April, in the open areas outside the 3 miles zone from the coast. In 1996 – 2005 its annual catches varied from 6 thousand tons to 19 thousand tons, making

on average 10.8 thousand tons. As compared with 1989 – 1995, when mean annual catch of whiting was equal to 17.6 thousand tons, the tendency towards reduction of both its catches and CPUE is observed.
Also, the whiting represents a complementary catch of the Romanian and Bulgarian fishermen. The level of fishing productivity is different from year to year, depending on the fishing effort (number of boats, nets, effective fishing days) and on the evolution of the hydro-climatic conditions and the anthropogenic factors. The catches realized between 2001 and 2008 ranged between 56 tons in 2008 and 1.167 tons in 2006, in the Romanian sector, and 2 tons in 2004 and 13 tons in 2003, in the Bulgarian sector (Maximov et al., 2009, in press) – Fig. 4.5.2.1.



	2001	2002	2003	2004	2005	2006	2007	2008
Romania	306	85	113	118	105	1167	274	56
Bulgaria	8	16	13	2	3	0	4	4

Fig. 4.5.2.1. The whiting catches in the Bulgarian and Romanian Black Sea area

4.5.3 Biological parameters

The determination of the biologic parameters represents an important objective for the establishment of the demographic structure, the growth parameters, as well as other parameters required for the study of recruitment, mortality, effective and biomass, divided into age classes.
In the Black Sea for the grounds with relatively slight fished off whiting population was characteristic of predominance of larger-sized fishes than in the grounds with wide shelf (Shlyakhov, 1983). In 1996 – 2005 in the grounds of intensive Turkish trawl fisheries one can observe tendency to reduction of mean length of fishes which became equal or even less than in Ukrainian waters. It is not quite typical and in our opinion it is the evidence of excessive intensity of fishery. Turkish scientists came to the same conclusion. Thus, according to materials of 2000 Genç *et al.* (2002) applying methods of LCA and Thompson and Bell found that modern whiting fisheries in the waters of Turkey is conducted with excessive MSY due to trawls with mesh size less than 22 mm. İşmen (1995, 2006) estimates existing fishing intensity as F=1.24 and considers possible to achieve optimal exploitation of whiting by means of decrease in fishing intensity or enforcement of a minimum allowable total length. Thus, whiting stock in the waters of Turkey may be characterized as excessively exploited.
In front the Bulgarian coast whiting catch length composition ranged between 50 and 230 mm and individual weight between 3.08–86.2 g. The highest percent belongs to the 115-120 mm group, followed by 135-140 mm and 155-160 mm. The length group 85-90 mm, accounts around 6% of the whiting bycatch. The rest of the length groups are very weakly presented in the landings (Maximov et al., 2009, in press). The analysis performed by (Raykov et al., 2008), show that highest value for L asymptotic of the whiting was calculated in Ukranian waters (39 cm) with the lowest growth rate (k = 0.106), accordingly. In Bulgarian and Romanian marine area the values are very similar and lower, as regards the asymptotic length (Table 4.5.3.1).

Table.4.5.3.1. Length growth of whiting in the North-Western part of the Black Sea (Raykov et al., 2008).

Merlangius merlangus euxinus(Nordm)						
$L_t = L\infty\ (1-e^{-k\,(t-t_0)})$	Age					
	1	2	3	4	5	6
Bulgaria						
$L_t = 29.83\ (1-e^{-0.157(t+2.49)})$	12.6	15.09	17.2	19.06	20.6	22.0
Romania						
$L_t = 26.3\ (1-e^{-0.16\,(t+2.19)})$	10.5	12.8	14.8	16.6	18.0	19.2
Ukraine						
$L_t = 39\ (1-e^{-0.106\,(t+1.324)})$	8.5	11.6	14.3	16.8	19.0	21.0

Overall, between 2004 and 2008, the whiting population on the Romanian littoral was homogenous, the length ranging between 40 and 230 mm/2.03–82.92 g, the dominant classes being those of 90-145 mm/5.50–23.84 g. The average body length was 107.45 mm, and the average weight 10.58g (Maximov et al., 2009, in press).

The analysis of age components during the entire Bulgarian fishing season emphasized the presence of individuals aged between $0;0^+$ to $5;5^+$ years, with a domination of individuals aged between $2;2^+$ years and $3;3^+$ years.

The analysis of age components during the entire Romanian fishing season emphasized the presence of individuals aged between $0;0^+$ to $4;4^+$ years, with a domination of individuals aged between$1;1^+$ years and 2;2+ years. The variation between sexes indicates a clear domination of the females (57.53%)(Maximov et al., 2009, in press).

4.5.4 The state of the whiting stock biomass

The problem of units for whiting stocks in the Black Sea has not been settled yet. Fisheries experts from the Black Sea Commission specify the stock as shared that is although this fish does not make long migrations; its whole stock (or two different stocks – Eastern and Western) is exploited by each Black Sea country in their waters and for its adequate assessment the analysis of the regional data is required.

For last 15 years only one research was undertaken (Prodanov *et al*., 1997) that made possible to produce assessments of abundance and biomass of whiting in the Black Sea (separately for the «western» and «eastern» parts of the Black Sea) by VPA method for the period of 1971 – 1993 on the basis of analysis of regional biological and fishing data.

For the period of 1996 – 2008 there were no such assessments, but available assessments of whiting stock value were made for limited grounds with its habitat area.

In Romanian waters in 1996 – 2008 whiting remained the most abundant among bottom fishes although its mean annual catch reduced as much as four times as compared with 1989 – 1995. Partially it was caused by reduction of fishing efforts as compared with previous period (Nicolaev *et al.*, 2003). The stock biomass was assessed at 6000-9000 tons by swept area method.

Along Georgian coasts for last 10 years whiting biomass assessments were not made, but on the basis of monitoring the scientists from this country make conclusion that at present the whiting abundance as well as of other bottom fishes increase (Komakhidze, Diasamidze, Guchmanidze, 2003).

In the Russian sector of the Black Sea trawl survey show that stocks of whiting and other *Gadidae* (*Gaidrosparus mediterraneus*) are estimated about 7.6 – 8 thousand tons and the annual TAC for whiting averages 2 thousand tons (Volovik, Agapov, 2003).

Along the Turkish coasts the total trawlable biomass of whiting in local areas were estimated by A. İşmen (2003). In 1992 the highest biomass between Sinop and Sarp (eastern Black Sea), which is an area, closed to trawl fishing – 30 thousand tons. In 1990 the biomass of whiting between Sinop and İğneada (western Black

Sea) was estimated within the range of 1.1 – 1.7 thousand tons. Even if for the period of 1996 – 2005 similar direct assessments of whiting biomass were made they were not published.
In 1992 – 1995 in the waters of Ukraine whiting biomass changed from 43 up to 70 thousand tons, on average 54 thousand tons, and for the subsequent decade – from 40 up to 68 thousand tons, on average 52 thousand tons (Shlyakhov, Charova, 2006). These data testify rather high inter-annual fluctuations but rather stable average level of whiting biomass in the specified areas where whiting specialized fisheries is almost absent and trawling fisheries are not conducted on the grounds with the densest whiting distribution.
By this reason the most realistic assessments of the stock abundance seem to be estimates according to the data of trawl surveys or surveys produced on the basis of analysis of fisheries with obligatory correction for unregistered catch. In order to make rough assessment of the present state of whiting stock and the extent of its exploitation by fisheries (underexploitation – exploitation at the target level – overfishing), let address to the assessments of allowable catch assessments in the various parts of the habitat area of this species.
As regards the levels of the reference points of whiting (Raykov *et al.*, 2008), in western part of the Black See the lowest level of F_{max} was established in Romanian waters: 0.52 and the middle level were established in Bulgarian waters: 0.61 and the highest - 0.68 was detected in Ukrainian waters. If to consider the value of this coefficient of natural mortality as constant and equal M = 0.70 (Prodanov *et al.*, 1997), and F_{max} = 0.60, so with favorable state of whiting population the highest level of annual capture makes up 33.6% of its initial stock.

4.5.5 Protection measures for whiting

Not considering in details the similarity and differences of various measures of Black Sea whiting fisheries in various countries we should note that fishing in Turkey is conducted without limitation of annual catch or the fishing efforts. This is one of the main reasons for whiting overfishing in the waters of that country. However, implementation and application of regular stock assessment practice, TACs, quotas without efficient enforcement of established measures will not ensure avoiding of overfishing and other negative impacts of fisheries on exploited species.

4.5.6 Availability of Data for assessment

As a gadoid species whiting can comfortably be assessed using age structured methods (Prodanov et al. 1997, Daskalov 1998b). STECF SG Black Sea-10-01 found out that data available in different national databases would allow to perform a quantitative assessment of this stock. Fisheries, biological (age and individual size and growth), survey data (trawl and juvenile surveys) and commercial CPUE from all countries need to be thoroughly compiled.

At the first stage data must be carefully screened and organised into age structured matrices. Age structured assessment methods such as XSA can be applied similar to turbot.
STECF SG Black Sea-10-01 collates the following metadata available in different national databases – Table 4.5.6.1. and landings statistics – Table 4.5.6.2.

Table 4.5.6.1. Data Availability by country.

Type of data	BG	RO	UKR	TR
Official landings	1925-2008	1950-2008	1978-2008	1980-2008
Illegal, Unreported Catch	no	no	1992-2002	no
Fishing effort and CPUE	yes	1980-2008	no	Some years
Number of fishing vessels	no		1978-1980	mixed
Research surveys -adult	2005-2009	yes	1978-1990, 1992, 1998	1990-1996, 2006-2008

Type of data	BG	RO	UKR	TR
Reserch surveys -juvenile	no	1995-2008	1973-1990	no
Hydroacoustic surveys	no	no	no	
Length composition	1996-2009	1980-2008	1973-2008	1990-1996, 2006-2008
Weight at length (survey, landings)	yes	1980-2008	1973-2008	1990-1996, 2006-2008
Age composition	2003-2009	1980-2008	1973-2008	1990-1996, 2006-2008
Weight at age (survey, landings)	yes	1980-2008	1973-2008	1990-1996, 2006-2008
Maturity at age	no	1980-2008	1973-1990	?
Natural mortality	?	1980-2008	1973-1990	?

Table 4.5.6.2. Whiting landings by countries (FAO Fisheries Statistics, GFCM Capture Production 1970 - 2006, 2007 – 2009 from National Fisheries Statistics of countries).

Year	Bulgaria	Georgia	Romania	Russian Federation	Turkey	Ukraine	Un. Sov. Soc. Rep.
1970	-	.	115	.	4312	.	.
1971	-	.	442	.	5855	.	-
1972	-	.	416	.	5284	.	-
1973	-	.	329	.	2476	.	-
1974	-	.	1305	.	2844	.	-
1975	454	.	346	.	3913	.	-
1976	347	.	541	.	4213	.	-
1977	218	.	1495	.	5726	.	-
1978	407	.	1345	.	21265	.	531
1979	71	.	1205	.	20778	.	11377
1980	30	.	618	.	6838	.	2690
1981	1	.	894	.	4669	.	2238
1982	4	.	800	.	4264	.	1513
1983	-	.	1080	.	11696	.	2381
1984	-	.	1192	.	11595	.	4738
1985	-	.	3138	.	16036	.	2655
1986	-	.	1949	.	17738		2652
1987	-	.	615	.	27103		2764
1988	-	5	1009	736	28263	1482	-
1989	-	5	2738	7	19283	579	-
1990	-	-	2653	235	16259	87	-
1991	-	-	59	-	18956	24	-
1992	-	70	1357	-	17923	.	-
1993	-	172	599	16	17844	5	-
1994	-	187	432	125	15084	64	-
1995	-	146	327	91	17562	17	-
1996	-	223	372	11	20326	3	-
1997	-	58	441	10	12725	29	-
1998	-	53	640	119	11863	55	-
1999	-	41	272	184	12459	18	-
2000	9	.	275	341	15343	20	-
2001	8	32	306	642	7781	18	-
2002	16	37	85	656	7775	9	-
2003	13	45	113	93	7062	21	-
2004	2	29	118	55	7243	43	-
2005	3	30	92	78	6637	30	-
2006	0.5	37	113	60	7797	15	
2007	16.114	41	118	22	11232	64	
2008	0.44	15	92	96	10986	9	
2009	2.27		1	52	15905	17	

4.6 Picked dogfish in the Black Sea

4.6.1 Distribution area, conditions and migration routes

Picked dogfish *(Squalus acanthias)* inhabits the whole Black Sea shelf at the water temperatures 6 – 15º C – Fig. 4.6.1.1.& Fig. 4.6.1.2. It undertakes extensive migrations. In autumn feeding migrations are aimed at the grounds of the formation of the wintering concentrations of anchovy and horse mackerel in the vicinity of the Crimean, Caucasus and Anatolian coasts. With their disintegration picked dogfish disperses all over the shelf. Reproductive migrations of viviparous picked dogfish take place towards the coastal shallows with two peaks of

intensity – in spring and autumn. The autumn migration for reproduction covers more individuals usually. The major grounds for reproduction of picked dogfish in the Ukrainian waters are located in Karkinitsky Bay, in front of Kerch Strait and in Feodosia Bay.
Picked dogfish belongs to long-living and viviparous fish; therefore reproduction process includes copulation and birth of fries. Near the coasts of Bulgaria, Georgia, Romania, Russian Federation and Ukraine the intense spawning season is in March-May. Two peaks of birth of juveniles can be distinguished – spring period (April-May) and summer-autumn (August-September, Serobaba *et al.*, 1988). To give birth of juveniles the females approach the coastal zone in depth 10 – 30 m (Maklakova, Taranenko, 1974). At this time males keep separately from females in depth 30 – 50 m. The birth of picked dogfish juveniles takes place at the temperature of water 12 – 18°C.
In autumn picked dogfish aggregates into large schools, accompanying anchovy and horse mackerel, which migrate to wintering grounds along eastern and western coast. During wintering the densest concentrations of picked dogfish are observed, where picked dogfish feeds intensively. They are associated, above all, with major wintering areas of anchovy in the waters of Georgia and Turkey. In the northwestern Black Sea in the waters of Ukraine and Romania in depth from 70-80 m down to 100-120 m abundant wintering concentrations of picked dogfish are also observed, where they are located on the grounds of whiting and sprat concentrations (Kirnosova, Lushnicova, 1990).

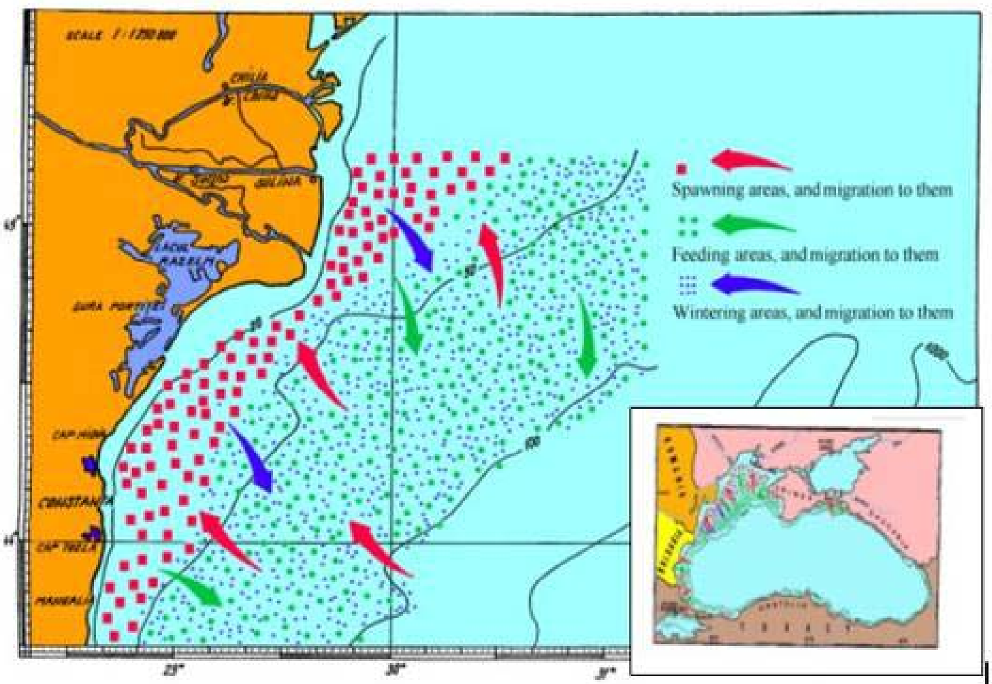


Fig.4.6.1.1. Distribution and migration routes of the picked dogfish at Romanian littoral (Radu et al.,2009b, 2010a).

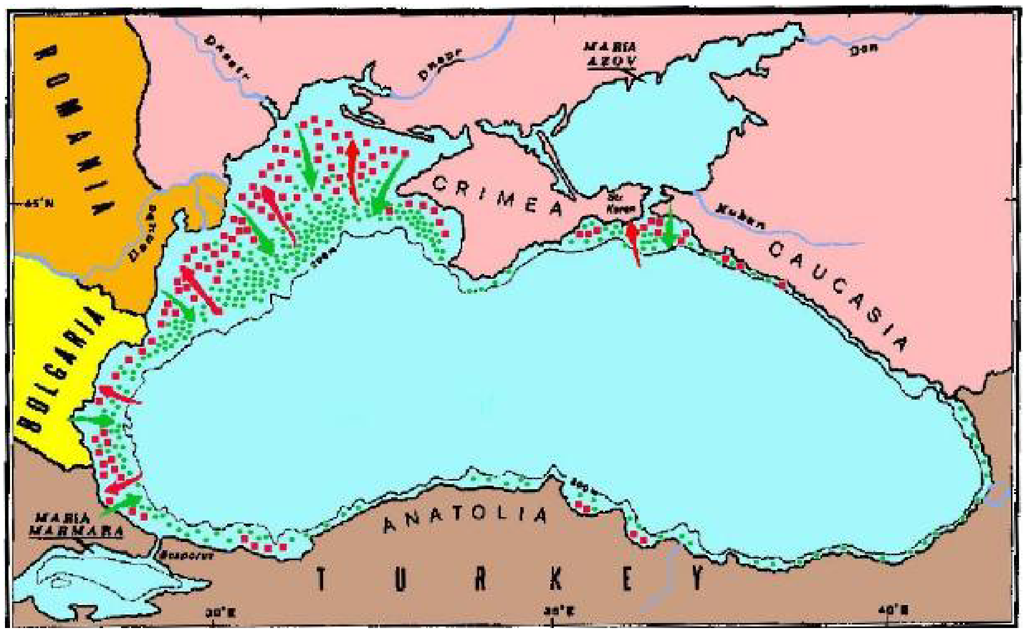


Fig. 4.6.1.2. Distribution and migration routes of the picked dogfish at Black Sea level.

4.6.2 Evolution of picked dogfish catches

In the Black Sea the largest catches of picked dogfish are along the coasts of Turkey, although this fish is not a target species of fisheries, being yielded as by-catch in trawl and purse seine operations mainly in the wintering period. In the 1989-1995 annual catches of Turkey are 1055-4558 t (Shlyakhov, Daskalov, 2008). In subsequent years, they have decreased about 2 times and did not exceed 2400 t. In the waters of Ukraine most of picked dogfish is harvested in spring and autumn months by target fishing with gill-nets of 100 mm mesh-size, long-lines, and as by-catch of sprat trawl fisheries. As in Turkish waters, in the last 20 years the maximum annual catches of picked dogfish are observed in 1989-1995, reaching 1200-1300 t. After 1994 the catches went down being between 20 and 200 t. In the rest of countries picked dogfish is harvested mainly as by-catch, annual catches are usually lower than the Ukraine. The maximum annual catches of picked dogfish in 1989-2005 were: Bulgaria - 126 t (2001), Georgia - 550 t (1998), Romania - 52 t (1992), Russian Federation - 183 t (1990). It should be noted that in the waters of Bulgaria, the highest catches were observed in the early 2000's. In Romania dogfish is caught mainly as by-catch of the sprat trawl fishery. The catches decreased very much because of decreasing of the trawling effort (Maximov et al., 2008b, 2010b; Radu et al., 2009b, 2010a,b).

In Turkey picked dogfish lost its commercial importance in recent years. In the last 20 years, the decrease of dogfish landing may be may be due to over-fishing (Demirhan , phD thesis,)

The landings of Picked dogfish by countries are given on Table 4.6.2.1.

Table 4.6.2.1. Picked dogfish landings by countries (FAO Fisheries Statistics, GFCM Capture Production 2006 - 2008)

Year	Bulgaria	Georgia	Romania	Russian Federation	Turkey	Ukraine
1989	28	217	30	135	4558	1191
1990	16	128	45	183	1059	1330
1991	21	18	26	67	2017	775
1992	15	14	52	15	2220	595
1993	12	131	6	5	1055	409
1994	12	45	2	11	2432	148
1995	80	31	7	90	1562	67
1996	64	71	-	19	1748	44
1997	40	1	-	9	1510	20
1998	28	550	-	6	855	38
1999	25	18	-	9	1478	94
2000	102	21	-	12	2390	71
2001	126	27	-	27	576	134
2002	100	65	-	19	316	97
2003	51.3	40	-	29	1840	172
2004	47.2	31	-	34	111	93
2005	14.5	35	-	19	102	75
2006	6.226	10	9	17	193	67
2007	23.98	2	17	28	91	45
2008	22.75		10	59	35	79
2009	9.46		3	14	156	47

4.6.3 Biological parameters and the state of the picked dogfish stock biomass

Picked dogfish is a major demersal predator, reaching the Black Sea the length of about 1.50 m. According to investigations conducted in former USSR waters, Kirnosova, (1993) found that the picked dogfish maximum age is 20 years. The parameters in VBGF and natural mortality parameters are:

Males:
K=0.029 t_0=-3.84; L_∞=272 cm; W_∞=47 kg; M=0.20÷0.23

Females:
K=0.026 t_0=-3.32; L_∞=303 cm; W_∞=196 kg; M=0.15÷0.20

Age and length, at which 50% of individuals are mature, are 10.49 years and 87.57 cm for males and 11.99 years and 102.97 cm for females, respectively. Mean biennial fecundity is 19.4 eggs and 12.9 pups. The linear relationship between fecundity and length is: F_e = 0.09 x TLp + 2.12 (r = 0.5) for pups and F_o = 0.27 x T Lp - 21.59 (r = 0.7) for eggs (Demirhan and Seyhan, 2007).

Life-history parameters and food diet of picked dogfish (*Squalus acanthias*) from the SE Black Sea were studied (Demirhan and Seyhan, 2007). Picked dogfish at age 1 to 14 years old were observed, with dominance of 8 years old individuals for both sexes. The length–weight relationship was $W=0.0040*L^{2.95}$and the mean annual linear and somatic growth rates were 7.2 cm and 540.1 g, respectively. The estimated parameters in VBGF were: W_∞=12021 (g), L_∞=157 (cm), K=0.12 ($year^{-1}$) and t_0=−1.30 (year). The size at first maturity was 82 cm for males and 88 cm for females. Mean biennial fecundity was also found to be 8 pups per female. The relationships fecundity–length, fecundity–weight and fecundity–age were found to be:

F=−17.0842+0.2369*L (r=0.93)
F=0.3780+0.0018*W (r=0.89)
F =−0.7859+1.1609*A (r=0.94), respectively.

The population data of picked dogfish at the Romanian Black Sea area are given in the figures bellow – Length frequency data - Fig. 4.6.3.1, Fig. 4.6.3.2, Fig.3.4.3.3, Fig. 4.6.3.4, Fig. 4.6.3.5 and average weights per length class – Fig. 4.6.3.6, Fig. 3.4.3.7, Fig. 4.6.3.8 (Maximov et al.,2010a,c; Radu et al., 2010a).

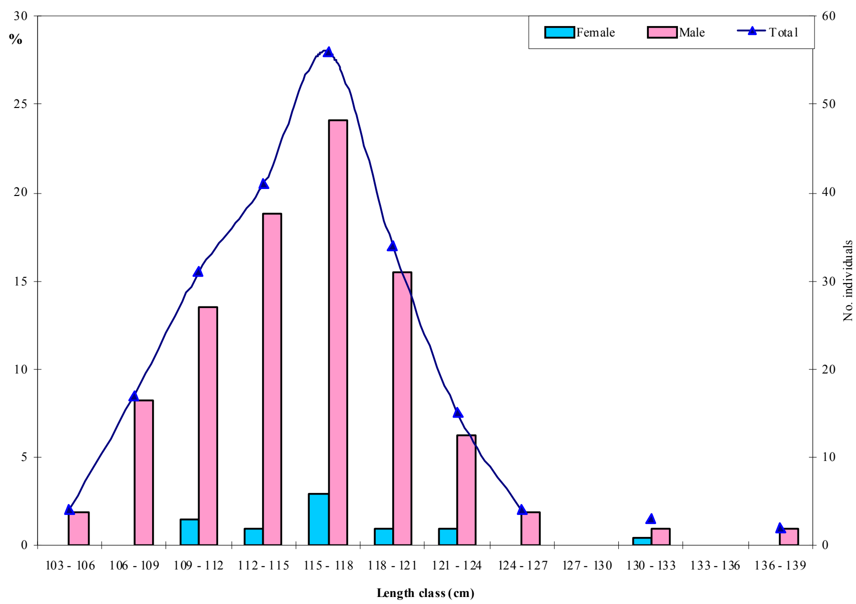


Fig. 4.6.3.1. Length frequency of Picked dogfish in 2009, Romanian Black Sea area.

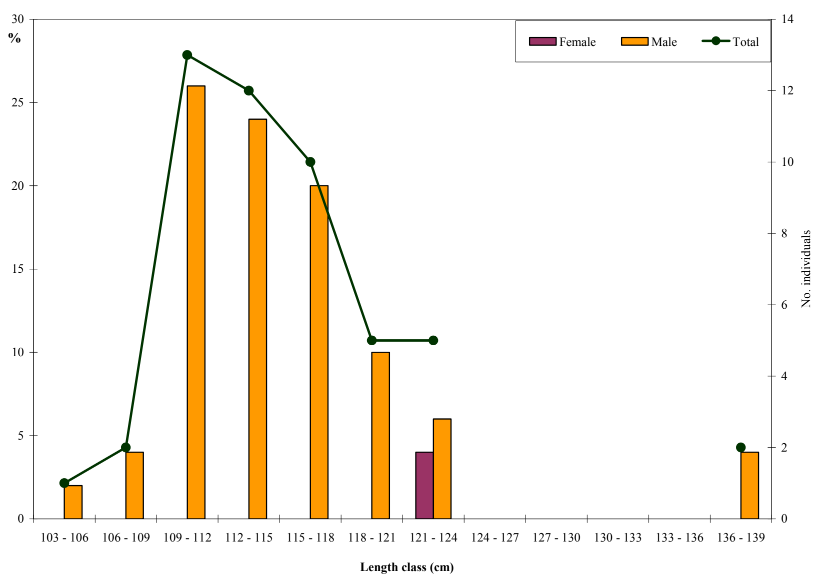


Fig.4.6.3.2. Length frequency of Picked dogfish in May 2009, Romanian Black Sea area.

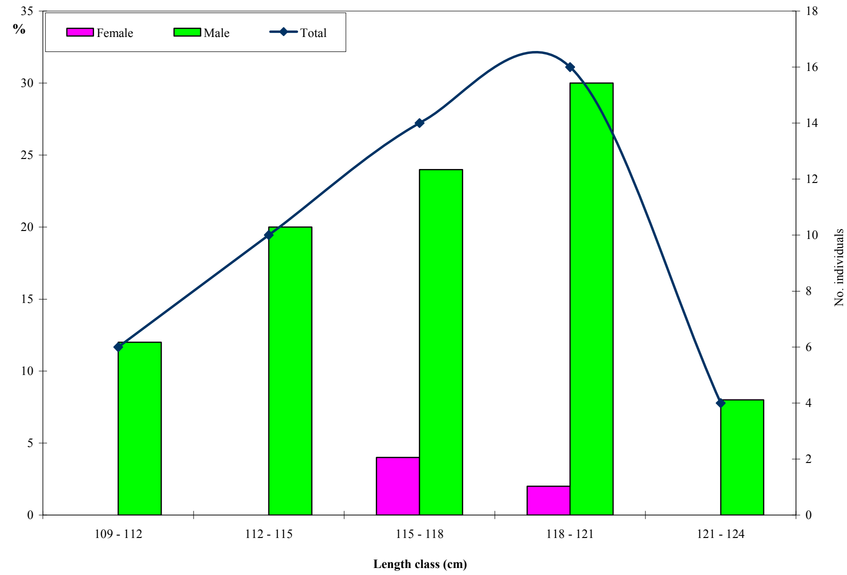


Fig. 4.6.3.3. Length frequency of Picked dogfish in June 2009, Romanian Black Sea area.

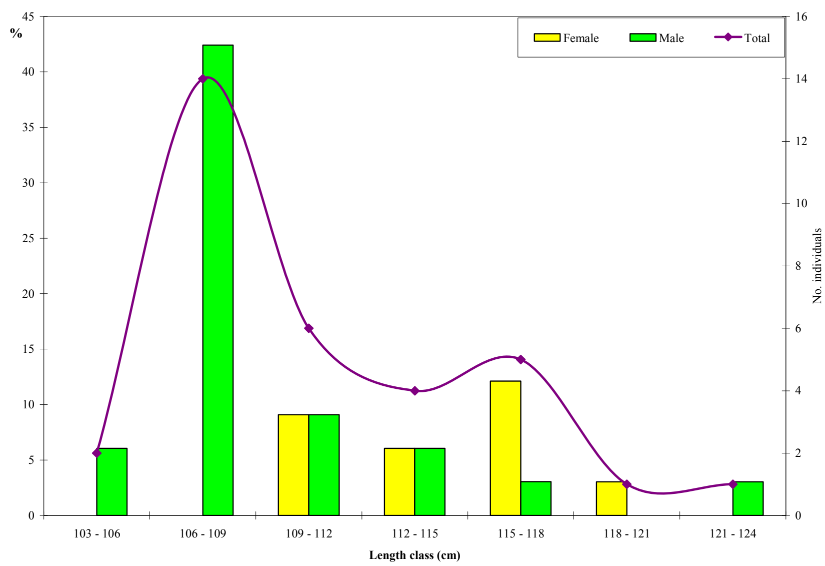


Fig. 4.6.3.4. Length frequency of Picked dogfish in October 2009, Romanian Black Sea area.

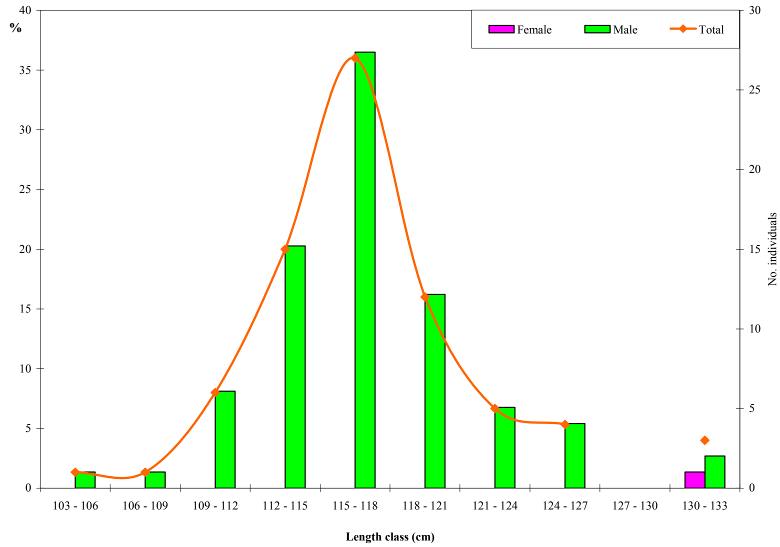


Fig.4.6.3.5. Length frequency of Picked dogfish in November 2009, Romanian waters.

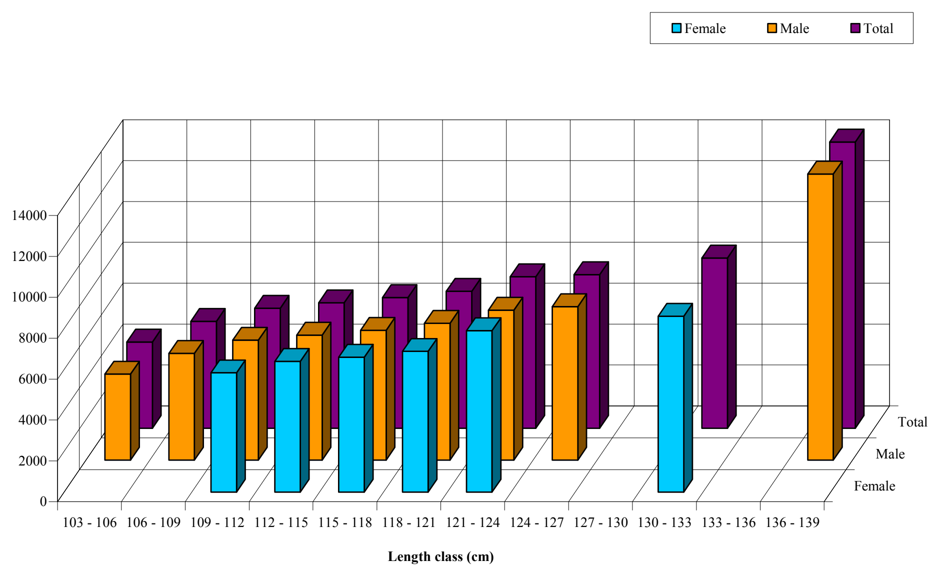


Fig.4.6.3.6. Picked dogfish mean weights (g) per length class and gender in 2009, Romanian Black Sea area.

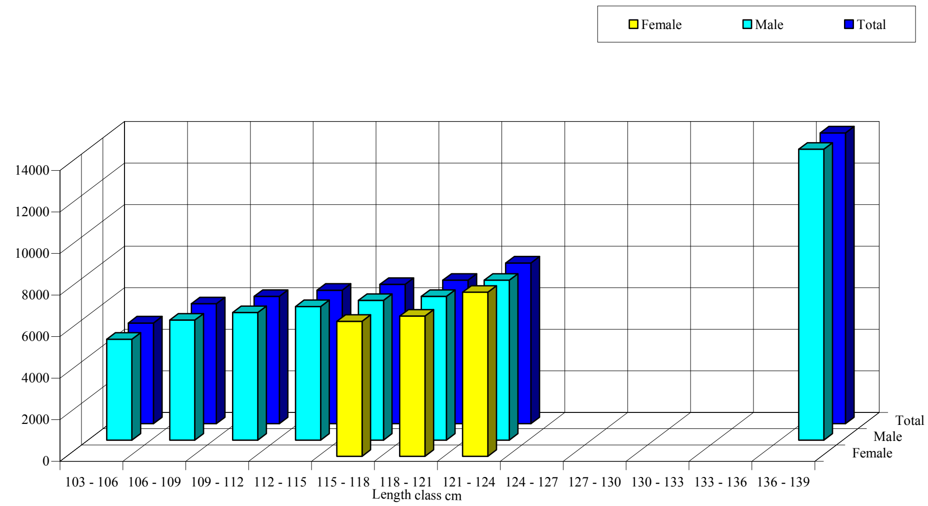


Fig. 4.6.3.7. Picked dogfish mean weights (g) per length class and gender in quarter II of 2009, Romanian Black Sea area.

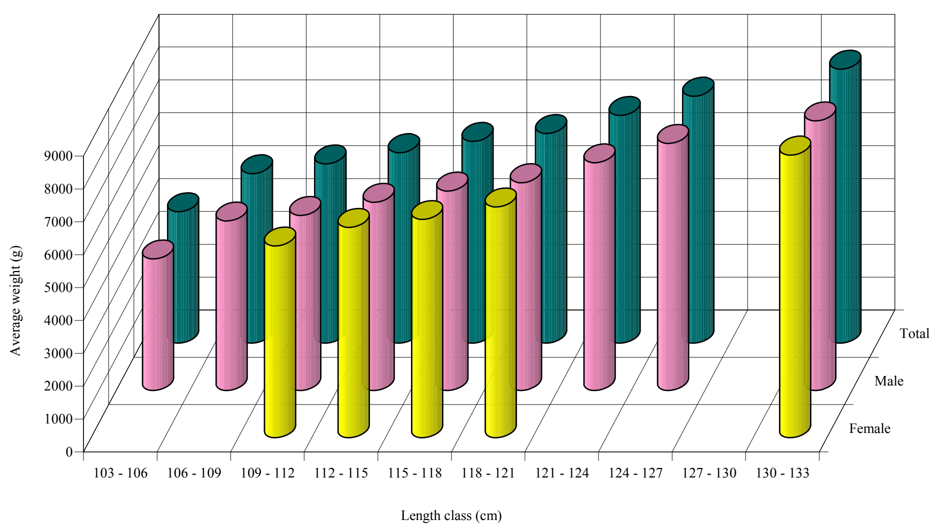


Fig. 4.6.3.8. Picked dogfish mean weights (g) per length class and gender in quarter IV of 2009, Romanian Black Sea area.

4.6.4 State of the picked dogfish stock biomass

In the former USSR and later in Ukraine, to assess the picked dogfish stock, the swept area technique using bottom trawl surveys, as well as dynamic model of an isolated population, were applied (Shlyakhov, 1997). The abundance and biomass of picked dogfish in the waters adjacent to Georgia, the Russian Federation and Ukraine were assessed. Whole population of picked dogfish in 1972 – 1992 was assessed by VPA (Prodanov *et al.*, 1997, Daskalov 1998). The obtained results from stock assessments in 1989 – 2005 are given in Table 4.6.4.1. According to the assessments, in 1989 – 2005 the stock of picked dogfish in the shelf area of the Black Sea and in Ukraine waters tends to be gradually reduced. Observed dynamics of stock corresponds with increasing CPUE in Turkish waters.

Table 4.6.4.1. Commercial stock of picked dogfish in the Black Sea and along the coast of the former USSR and in the water of Ukraine, th. tones.

Years	Whole Black Sea shelf	Waters of Ukraine, the Russian Federation and Georgia		Waters of Ukraine	
	VPA	Trawl survey	Modeling	Trawl survey	Modeling
1989	117.8	58.5	63.5	34.6	-
1990	112.9	58.7	63.2	48.8	-
1991	97.9	17.2/69.9*	64.0	14.4/58.5*	-
1992	90.0	62.9	60.3	56.9	-
1993	-	-	57.1	30.2	-
1994	-	-	52.9	36.0	42.1
1995	-	-	-	-	37.6
1996	-	-	-	-	32.1
1997	-	-	-	-	31.0
1998	-	-	-	32.0	30.8
1999	-	-	-	-	28.0
2000	-	-	-	-	24.3
2001	-	-	-	-	22.3
2002	-	-	-	-	21.0
2003	-	-	-	-	22.1
2004	-	-	-	-	22.3
2005	-	-	-	-	21.0

* stock assessment is reduced to the average area of the registration (survey) zone.

According to the assessments of Prodanov *et al.* (1997) and Daskalov (1998) picked dogfish stock has increased until 1981, after that it began to decrease. The authors explained the increase in picked dogfish with the increased abundance of main food species (whiting, sprat, anchovy and horse mackerel), and its subsequent reduction partially with intensification of the dogfish fishery during the period 1979 – 1984.

In Romanian waters the swept area method was applied for stock assessment of picked dogfish. Results for estimated picked dogfish biomasses in May and November of 2009 in Romanian waters are given on Table 4.6.4.2 and Table 4.6.4.3 and Fig. 4.6.4.1 & Fig. 4.6.4.2 (Maximov et al.2010b,c; Radu et al. 2009 a,b, 2010a,b). In May 2009 the biomass of dogfish was evaluated at 741 t, extrapolated to 967 t for the shelf till 50 Nm from the shore.

Table 4.6.4.2. Assessment of picked dogfish biomass in May 2009 by demersal trawl, Romanian Black Sea area.

No. polygon	Surveyed area (Nm^2)	Range (t/Nm^2)	Average (t/Nm^2)	Total t in polygon (t)	Notes
1	1,227.13	0.00	0.00	0.0	Extrapolated at 967 t for the shelf till 50 Nm from shore
2	242.25	0.27 – 0.43	0.35	84.78	
3	165.00	0.23 – 0.28	0.26	42.90	
4	116.00	0.28	0.28	32.48	
5	724.25	0.53 0.76	0.63	456.27	
6	478.25	0.23 – 0.28	0.26	124.35	
7	265.63	0.00	0.0	0.00	
Total	3,218.5			740.78	

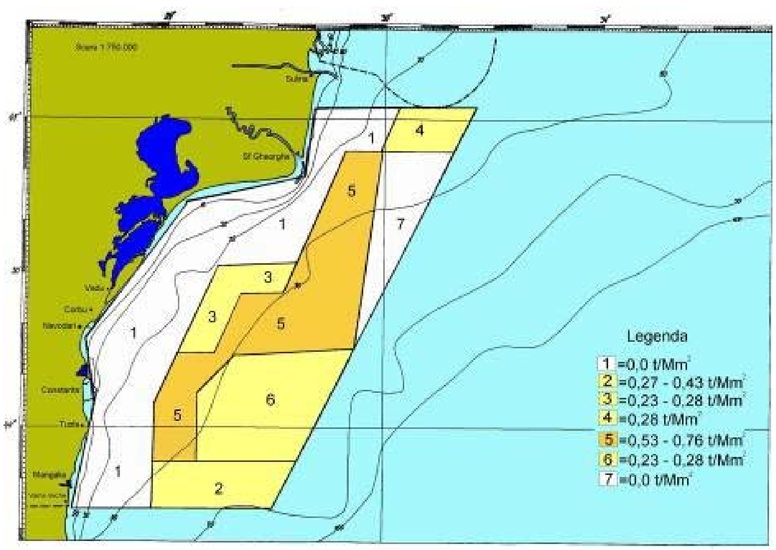


Fig.4.6.4.1. Distribution of picked dogfish catches during demersal trawl survey in May 2009, Romanian Black Sea area.

In November 2009 the biomass of picked dogfish was assessed at 2,015 t, extrapolated at 2,541 t for the shelf till 50 Nm from shore.

Table 4.6.4.3. Assessment of picked dogfish biomass by demersal trawl in November 2009, Romanian Black Sea area.

No. polygon	Surveyed area (Nm^2)	Range (t/Nm^2)	Average (t/Nm^2)	Total t in polygon (t)	Notes
1	926.25	0.26 – 0.81	0.41	379.76	Extrapolated at 2,541 t for the shelf till 50 Nm from shore
2	2,404.13	0.39 – 2.04	0.68	1,634.81	
Total	3,330			2,015	

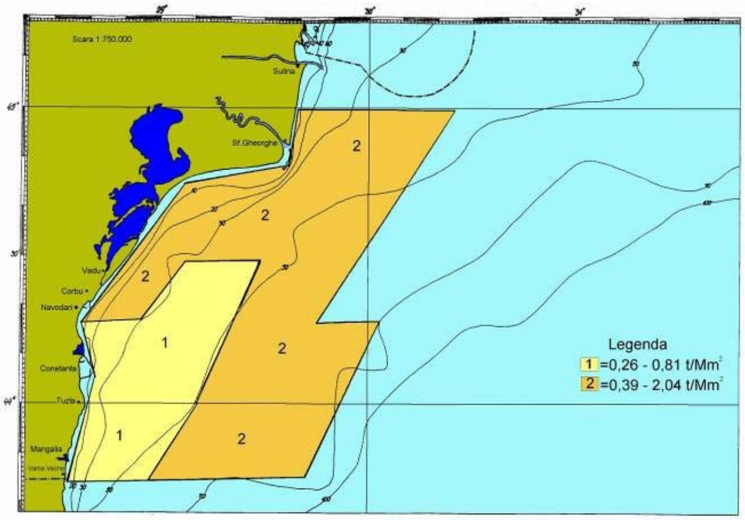


Fig. 4.6.4.2. Distribution of picked dogfish catches during demersal trawl survey in November 2009, Romanian Black Sea area.

4.6.5 Availability of data for assessment

Given the practice of previous studies, the picked dogfish can be assessed using age-structured methods (Prodanov et al. 1997, Shlyakhov, 1997, Daskalov 1998). Fisheries, biological (age and individual size and growth), trawl survey data and commercial CPUE from all countries need to be thoroughly compiled (Table 4.6.5.1).

At the first stage data must be carefully screened and organized into age structured matrices. Age structured assessment methods such as XSA can be applied similar to turbot.

Table 4.6.5.1. Data Availability by country

Type of data	**BG**	**RO**	**RF**	**TR**	**UKR**
Official landings	1970-2009	1980-1995 2006-2009	1988-2009		1988-2009
Illegal, Unreported Catch		no	no		no
Fishing effort and CPUE		no			1989-2009
Number of fishing vessels		no	no		no
Research surveys		2003-2010			1989-1993, 1998
Length composition	2006-2010	2003-2010			1988-2009
Weight at length (survey, landings)	2006-2010	2003-2010			1988-2009
Age composition		no			1988-2009
Weight at age (survey, landings)		no			1988-2009
Maturity at age		no			1989-1993, 1998
Natural mortality		no			1989

4.7 Rapa whelk in the Black Sea

4.7.1 Distribution areas and biology

Rapa whelk (*Rapana venosa)* was introduced into the Black Sea in the 1940s and within a decade spread along the Caucasian and Crimean coasts and to the Sea of Azov. Its range extended into the northwest Black Sea to the coastlines of Romania, Bulgaria and Turkey from 1959 to 1972 (Global Invasive Species Database (http://www.issg.org/database). *R. venosa* is well established in the benthic ecosystem of all Black Sea coastal states and has exerted significant predatory pressure on the indigenous bivalves (Black Sea TDA, 2008).

The impact on bivalve populations is variable and ranges from rather mild along the Romanian coast possibly due to suboptimal environmental conditions, moderate in Bulgarian and Turkish Black Sea, and severe along Russian and Ukrainian coasts, where the whelk has been blamed for local exterminations or major declines in the numbers of other bivalves (Black Sea TDA, 2008).

In the Black Sea, *Rapana venosa* occurs on sandy and hard-bottom substrates to 45 m depth. The highest abundance occurs in the Kerch Strait at the entrance to the Sea of Azov, near Sevastopol and Yalta (Ukraine), and along the Bulgarian coast (ICES, 2004). *R. venosa* is a prolific, extremely versatile species tolerating low salinities, water pollution and oxygen deficient waters. Rapa whelk becomes mature at the age of 2-3 old and has 8-9 years life span. Preferred habitats are shell substrates and shell bottoms with varying degrees of silting, but on silt beds the Rapa whelk occurrence is not high. The species demands lower limit of salinity about 12 ‰. At low temperatures the activity of Rapa whelk falls and if the temperature falls to 10° C, the species can stop feeding. Local migrations of Rapa whelk have been associated with seasonal changes of water temperature and have been oriented toward the shore in the period of water heating during spring-summer season, and towards to depths in the autumn-winter cooling. Ciuhcin (1984) describes the reproductive period of *R. venosa* in the Black Sea as July to September, corresponding to a temperature window of 19^oC to 25^oC. Sahin (1997) reports a spawning period of May to November in the eastern Black Sea. Females lay eggs in cocoons attached to the substrate. Each egg capsule contains 200-500 eggs. Pelagic larvae of Rapa whelk feed on nanoplankton algae and their adults feed mainly on bivalves of families Cardiidae, Mytilidae, Veneridae, Archidae (GFCM:SAC12/2010). Looking for prey Rapa whelk is able to move on rather large distances. The speed of movement makes up from 5 till 20 cm/min. In some periods of a year it buries itself into the sediment.

Introduction of this predatory mollusk into the ecosystem of the Black Sea turned out to be a catastrophe for oyster biocenoses. Distribution of Rapa whelk is associated with reduction in area and density of mussel settlements, in particular near the coasts of Anatolia and Caucasus. In the Ukrainian waters Rapa whelk destroyed the oyster banks in the area of the Kerch Strait and in Karkinitsky Bay, biocenoses of other mollusks associated with depth down to 30 m suffered as well.

4.7.2 State of the fisheries

Rapa whelk has become a commercially valuable resource with high demand on the international market. The commercial value of this resource increased initially in Turkey during 1980s and then in Bulgaria (1990s). In Romania, medium scale 'subsistence' harvesting is likely to develop into an export-oriented industrial-scale enterprise in future years. In Ukraine *R. venosa* uses are limited to local subsistence fishery and souvenir manufacture/trade (Black Sea TDA, 2008, BSC SOE, 2008).

Positive economic effects from *R. venosa* fishery are counteracted by negative ecological side-effects of destructive fishing practices used in Turkey and Bulgaria where *R. venosa* is fished with dredges and beam trawls, in the latter country illegaly (Black Sea TDA, 2008). In contrast, in Romania *R. venosa* is selectively fished by SCUBA divers, a sustainable method which does not disturb the habitat or involve by-catches of other animals.

In Bulgaria, Rapa whelk fisheries started in 1994 by method of scuba diving, but later illegal use of beam trawls have been also observed. For that reason, the official landings are misreported to some extent. Due to fact, that the Rapa whelk products are export orientated, the real value of catches could be estimated by official export data.

Turkey has been conducting large-scale harvesting of Rapa whelk since the mid -1980s. The Turkish catch remained, however, much higher than other countries, followed by Bulgaria (BSC SOE, 2008, GFCM Capture Production 1970 – 2006, National Fisheries Statistics of Bulgaria,Romania, Turkey,Ukraine, Russian Federation 2007 - 2009) – Table 4.7.2.1.

Table 4.7.2.1. Rapa whelk landings (t) by countries (FAO Fisheries Statistics, GFCM Capture Production 1970 – 2006 and National Fisheries Statistics 2007 - 2009).

Year	Bulgaria	Romania	Turkey	Georgia	Russian Federation	Ukraine
1970	.	-	-	.		.
1971	.	-	-	.		.
1972	.	-	-	.		.
1973	.	-	-	.		.
1974	.	-	-	.		.
1975	.	-	-	.		.
1976	.	-	-	.		.
1977	.	-	<0.5	.		.
1978	.	-	-	.		.
1979	.	-	65	.		.
1980	.	-	-	.		.
1981	.	-	-	.		.
1982	.	-	-	.		.
1983	.	-	235	.		.
1984	.	-	122	.		.
1985	.	-	78	.		.
1986	.	-	2030	.		.
1987	.	-	643	.		.
1988	.	-	7195	-		-
1989	.	-	9239	-		-
1990	.	75	6094	-		-
1991	.	70	3738	-		-
1992	.	110	3519	-		14
1993	.	45	3668	-	29	3
1994	3000	-	2607	-	2	5
1995	3120	-	1198	700	.	303
1996	3260	-	2447	711	1	376
1997	4900	-	2021	118	440	476
1998	4300	-	3998	.	46	369
1999	3800	-	3588	.	45	619
2000	3800	-	2145	184	182	913
2001	3353	-	2614	517	224	395
2002	698	-	6241	503	56	91
2003	325	-	5501	295	62	149
2004	2428	-	14035	65	62	159
2005	511	-	12156	70	122	161
2006	2773	-	10944	300	21	189.2
2007	4310		13106			201
2008	2872	0.085	11268			135
2009	2213.94	1.766	5460			190

In Turkey, harvesting of Rapa whelk has been firstly permitted by MARA in 1983. The fishery sector expanded including fishermen, commission agents, industrial enterprises, especially in the Eastern Black Sea. In the beginning, 225 artisanal fishermen were operating with dredges (algarna) along eastern Black Sea, but the number of fishermen reached 421 in the next ten years (Zengin and Knudsen, 2006). Analysis of fisheries along the eastern coast of Turkey (Samsun Province) showed that number of vessels using dredges for Rapa whelk harvesting increased in 2000 - 2005, especially in the vessel group 33 -149 HP. These are typical boats that combine Rapa whelk dredging, bottom trawling and net fishing (Knudsen and Zengin, 2006). The large-scale implementation of dredges has a destructive effect on the bottom biocenoses.

The Turkish fishermen, working on Rapa welk, mostly have vessels with 6-17 m in length. A single dredge is used in vessels smaller than 8 m and the larger ones previously have used a pair of dredges. At present, the use of double dredges is prohibited by government regulations, but fisherman use them when fishing at night illegally. The number of vessels in Samsun district was 421 by 2005 and nearly half of them (232) had no licences for Rapa whelk fishing. These vessels intensely operate in inshore waters between depths of 5 and 33 m of dept (but mostly around 13 m).

The landings of Rapa whelk in Eastern Black Sea was 10 000 t in 1989, averagely changed around 3 000 tons (1 - 6 tonnes) between 1990 and 2000 according to TUIK official data. In the following decade landing of Rapa whelk increased and reached its maximum as 14 000 t in 2004. This trend continued more or less stable (11 000-14 000 tons) until 2009. A sudden decrease was recorded in 2009, as the landings dropped to 6 000 t. The increase in 2000 - 2010 may be explained by the depletion of major demersal stocks in the area and switching to Rapa whelk to take advantage of its high export value.

Until the early1990s, along the Ukrainian coast, Rapa whelk was harvested in an amateurish way for fine shells used as souvenirs (BSC SOE, 2008). At the same time the meat of harvested mollusks was thrown away, or rarely used to feed animals and more rarely as an exotic meals for humans. Along the coasts of Ukraine the densest concentrations of Rapa whelk are found in depth 3-15 meters along the coast of the Crimea from Mezhvodnoye (the Karkinitsky Bay) to the Cape Takil and in the Kerch Strait. In this area a specialized harvesting (by Khizhyak's drags and hand harvesting by Scuba divers) for Rapa whelk has been conducted since 1995. In the Black Sea the maximum harvesting of Rapa whelk was observed in 2000 at the level of 913 tons, among which 325 tons were harvested on the ground Cape Takil – Feodosia by 19 teams of harvesters, equipped with aqualungs and by 7 drags. In the Kerch Strait the maximum harvest of Rapa Whelk made up 49 tons in 2007.

4.7.3 State of rapa whelk stocks

Research on biological parameters, distribution and stock assessment (by drags and visual divers surveys) of Rapa whelk in the Ukrainian territorial waters were undertaken in 1990, 1994 and 1998 in the area from Takil Cape to Chauda Cape. Stocks were respectively assessed as 2.8 thousand tons, 1.5 thousand tons and 1.3 thousand tons. The former two assessments belonged to the initial commercial exploitation of this ground, the latter – to the period of the intensive fisheries. Reduction in Rapa whelk stocks from 1.5–2.8 thousand tons (virgin population in 1990-1994) down to 1.3 thousand tons (exploited population in 1998) is the evidence of drag fisheries impact. At the same time it is known that instead of the permitted by the Fisheries Regulations Khizhnyak’s drag which is a sparing (protective) fishing gear of this class, knife-edge drags were widely used, affecting greatly the bottom biocenoses. In 1994 Rapa whelk stocks were assessed along the southern and western coasts of the Crimea from Cape Ilya to the Cape Evpatoriisky. Rapa whelk stock was estimated in this area as 14 thousand tons, and the limit for its harvesting in the waters of Ukraine has been established to 3 000 t. After 2000 small-sized Rapa whelks of 50-60 mm were predominant in the catches from this ground. The causes of the observed rejuvenation of Rapa whelk population at present are difficult to establish without scientific research activities. The most probable cause is overfishing, accompanied by the intensive harvesting of individuals of older ages (more than 75 mm long) and great amount of the illegal harvest. Since 2002 annual limit for Rapa whelk harvesting in the Ukrainian waters has been reduced down to 400 tons. After this reduction the fishing intensity has greatly decreased and by mid 2000s some increase in abundance and individual size has been noticed near the coast of the Crimea. In Ukrainian waters of the Kerch Strait in recent years surveys of Rapa whelk are made regularly (Fig. 4.7.3.1).

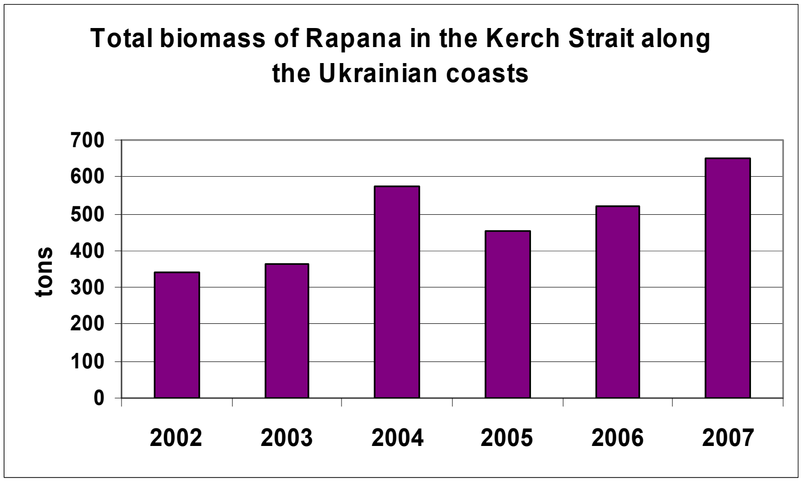


Fig. 4.7.3.1. The dynamic of Rapa Whelk biomass in the Kerch Strait, Ukraine.

The investigations conducted in the Black Sea shelf area and Kerch Strait found that the Rapa whelk age upper limit is 9 years and growth parameters in VBGF and natural mortality coefficients (M at age) are:

$K=0.687$ $t_0=-0.014$; $L_\infty= 9.55$ cm; M_t: $M_2= 0.12$, $M_3= 0.54$; $M_4= 1.28$, $M_5= 1.40$

Prior to the start of Rapa whelk regular harvesting in Bulgaria, the biomass on the coastal grounds between Kaliakra and Pomorie have been estimated at about 2 thousand tons (Prodanov and Konsulova, 1993). Taking into account all the area and the buried part of mollusks, its total biomass is assessed as 7.5 thousand tons. The average shell length of Rapa whelk in 1984 was 71.1 mm (Prodanov and Konsulova, 1995). Bottom trawling and dredging have officially been forbidden, but these fishing gears are still illegally used in Rapa whelk fishery. According to the assessments of the Private Bourgas Fishery Association, Rapa whelk landings are almost 7 times higher than the official report 8557 tons in 2005 (TDA Technical Task Team National Experts, Bulgaria report, Raykov, 2006).

Growth rate of *R. venosa* along Bulgarian Black Sea coast was investigated and population parameters and natural mortality coefficient were estimated (Prodanov et.al, 1995). The following values of von Bertalanffy parameters were established (Prodanov et.al, 1995):

$L_\infty= 123.98$ mm	$W_\infty = 423.75$ g
$k = 0.214$	$k = 0.1989$
$t_0 = - 0.0822$	$t_0 = - 0.2203$

The mean value of natural mortality coefficient was estimated at 0.5 (Prodanov et.al, 1995).

Distribution of Rapa whelk catches by size and age groups during the survey in 1992 (Prodanov et.al, 1995) is given on Fig. 4.7.3.2.

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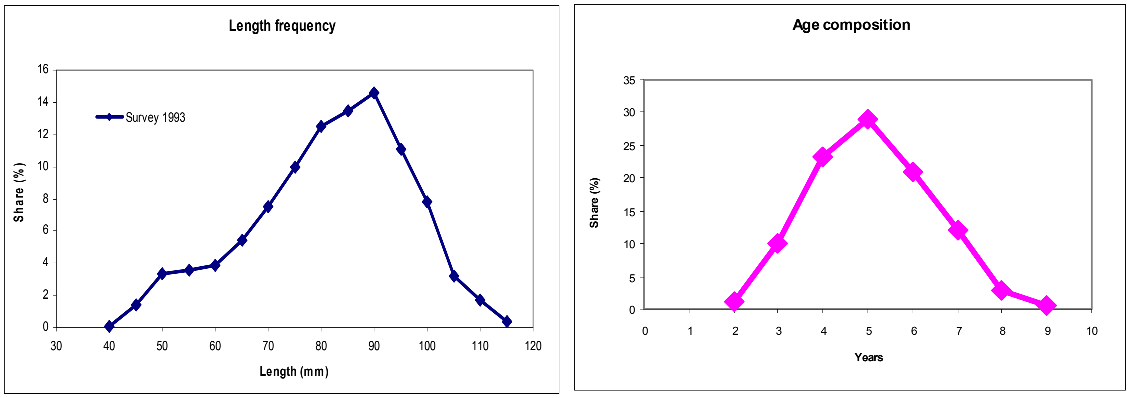


Fig. 4.7.3.2. Size and age structure of *R. venosa* in 1992 along the Bulgarian Black Sea coast (after Prodanov et.al, 1995).

Illegal bottom trawling for harvesting of *R. venosa* along the Bulgarian Black Sea shelf has raised ecological concerns with respect to the benthic communities and especially the mussel beds. The population decline of the habitat-structuring species *Mytilus galloprovincialis* in the impacted areas was accompanied by degradation of the associated benthic community from "mussel bed" type to "silt bottom" type dominated by opportunistic polychaetes and oligochaetes (Zenetos et al, 2003).

National Agency of Fisheries and Aquaculture start to collect data for export of Rapa whelk and CPUE data, which could be used for estimation of real value of landings – Table 4.7.3.1 and Table 4.7.3.2.

Table 4.7.3.1. Export data of Bulgaria for *R.venosa* in 2009.

Origin BULGARIA	Net weight (kg)
Frozen Rapa whelk	146164
frozen sweetbread from Rapa whelk	326178
frozen meat from Rapa whelk	572102
frozen meat from Rapa whelk with shells	59204
Total	**1103648**

Table 4.7.3.2. Catch per unit effort (kg/h) of Bulgaria on Rapa whelk fishery by fleet segments in 2008 and 2009.

leet Segment / Average CP	LOA>0<6		LOA=>6<12		LOA=>12<18		LOA=>18<24		LOA=>24<40	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Rapana RPN	305.69	238.38	461.88	529.95	722.83	611.99	744.84	768.24	no	no

In the Romanian Black Sea sector, *R. venosa* was first found in 1961, in the Danube delta (Grossu, 1964), from where it rapidly spread towards the South, becoming a common species (Gomoiu, 1972). Today it is encountered on all types of substrate (rocky, sandy, or muddy) at depths between 3 and 45 m.

Investigations on *R.venosa* were conducted in the Romanian Black sea area during the period 2006-2008 and the following results were obtained:

1. The average length of the about 7,000 *Rapana* individuals selected ranged between 35 and 120 mm, the modal length being 90 mm, while the average one - 87.08 ± 0.36 mm. The average numeric density is 0,88 ± 0,02 ind/m^{-2}, which corresponds to a total population of 100,16 ± 2.25 million *Rapana* individuals on the rocky substratum (113.53 km^2) on the Romanian sector of the Black Sea littoral.
2. The total number of capsules laid by the female during one reproductive season (laboratory rearing) varied between 184 and 450, while the number of eggs in one capsule was 976. Thus, the fecundity was estimated between 179.000 and 400.000 eggs/ind^{-1}/an^{-1}.
3. The size of the eggs is 230-250 µm, while that of the newborn larva shell is 0.41 x 0.3 mm. The intercapsular development duration until hatching was of 14-17 days, at a 20°C temeparture. The veliger larvae are planktotrophes and can survive in the plankton for a long time (80 days), ensuring the long distance spreading, provided they find sufficient food in the plankton. If the plankton contains sufficient food, the larvae can metamorphose and start their benthic life in only 5-7 days.
4. The population diversity on the Romanian Black Sea Sector is higher than those of the populations in the Northern Adriatic Sea, despite the smaller distances between the collecting stations. This high diversity is probably due to the fact that Black Sea populations are 10-30 years older than those in the Mediterranean.
5. The *R. venosa* stocks in the Romanian Black Sea sector were estimated for the first time. The underwater transects method for stock evaluation was used. The commercial *R. venosa* stock was estimated around 13.19 ± 0.42 thousand tons, while the TAC level recommended for the fishery management is la 5.7 ± 0.2 thousand tons.
6. The age of *R. venosa* was determined for the first time through sclerochronology.
7. The first microsatellite library for the *R. venosa* species was created and six microsatellite loci were described.
8. The age at the first breeding was determined at 2-4 years, corresponding to a shell length of 70-80 mm. In order to ensure at least one reproduction during the life span of an individual, it was recommended to increase the present minimum size of capture of 50 mm, to 80 mm.
9. The imposex phenomenon (developing penis and defferent vessels in *R. venosa* females) caused by TBT pollution was demonstrated for the first time in the Black Sea.

The official catches reported at the Romanian littoral are: in 2008 - 85 кg and in 2009 – 1761 kg. The catches are obtained by Scuba divers.

The Turkish investigations concerning biomass distribution of Rapa whelk by depth and season indicates that 76.5% of the population inhabits the depths of 0-15 m from the shore, 22.5 % in 15-35 m, and 1.0% - in depths over 35m. The major factor determining the seasonal distribution is the sea water temperature. In summer, 62.5% of the population distributes in near shore of 0-15 m depths when the temperature reaches its maximum (Zengin, 2005). By the end of the reproduction period and the decrease in sea water temperature (September), Rapa whelk moves to deeper waters and buries in the sediment.
The maximum catch is obtained in summer in studies carried out with commercial dredges along Samsun in 2005 (Fig. 4.7.3.3). The catch per unit of dredges in June and July is estimated as 70 and 100.9 kg/hour/vessel. The CPUE decreases in spring and autumn. It reaches to its minimum in spring; 5.7 and 26.3 kg/hour/vessel for April and May, respectively. It is considered to be related to temperature fall and the movement of *Rapana* to deeper waters.

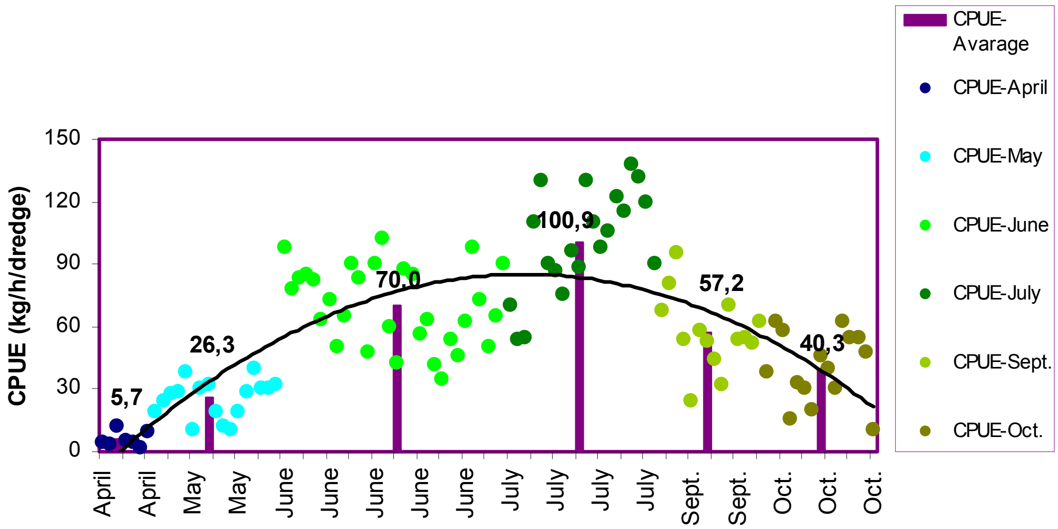


Fig. 4.7.3.3. CPUE data obtained from rapa whelk commercial dredges in Samsun coasts for 2005.

The significant increase in Rapa whelk abundance has been observed since 1990. The specialised feeding of Rapa whelk on bivalves creates a high predation pressure and competition for food. The scarcity of food lead lower growth rates of *Rapana* and prevents it from reaching harvestable size.
The overexploitation of eastern stocks lead to a decline by the late 1990s and to significant difference in mean length between the western (Samsun and Bulgaria) and eastern (Georgia and Ordu) stocks. The mean length is 4.7 cm (1.1-10.7 cm), 6.4 cm (2.5-11.7 cm) and 6.9 cm (3.5-11.9 cm) for eastern stocks, Samsun (Kizilirmak and Yeşilirmak shelf area) and western stocks, respectively (Fig.3.5.3.4) (Knudsen and Zengin, 2006). As a result fishermen from the eastern have moved to Samsun area and further west. It is also confirmed by a number of studies that the decrease in mean length corresponding to an increase in biomass (Ünsal, 1989, Düzgüneş et al. 1992, Emiral, 2003, Zengin, 2005). The mean length was recorded as 11.0 cm in 1986 (Ünsal, 1989), 6.7 cm in 1991 and 6.5 in 1995 (Düzgüneş et al. 1992) 5.4 cm in 1999 (Emiral, 2003) and 4.5 cm in 2003 (Zengin, 2005) (Fig. 4.7.3.5).

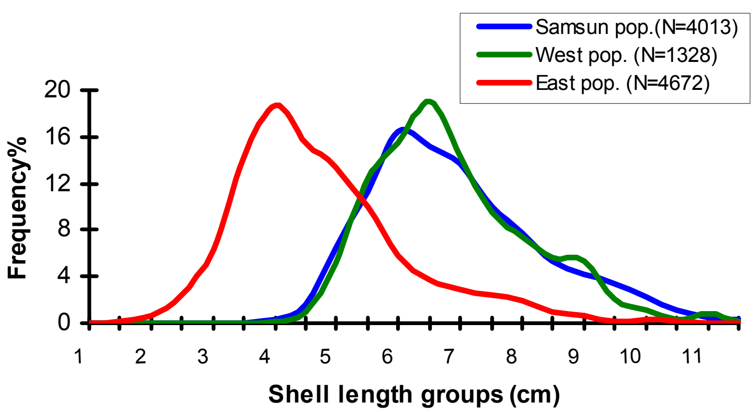
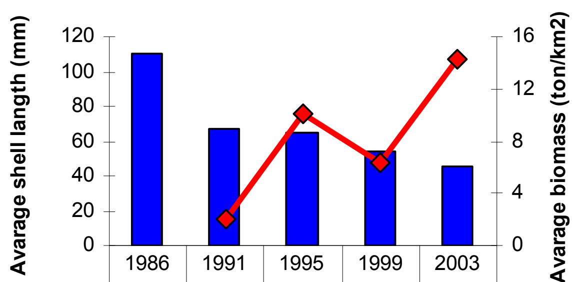


Fig. 4.7.3.4. The length frequency distributions of Rapa whelk caught by commercial dredges in fishing season 2005, along eastern coasts (Georgia-Ordu), Samsun and western coasts (Samsun-Bulgaria)

The possible reasons of the decrease in mean length may be considered due to:
1. The overexploitation of larger length groups due to high demand for market and export.
2. The reduction of natural food sources as a result of intense Rapa whelk predation

The Rapa whelk has no effective natural predators in Black Sea. Its feeding depends dominantly on mussels (Cesari and Mizzan, 1993) and its high predation have lead to the depletion of nearly all stocks of *M.*

galloprovincialis, C. gallina, A. cornea along the Turkish coast from Georgia border to Ünye/Terme. It was recorded that 99% of *C. gallina* population is composed of empty shells in 2002/2003 (Dalgıç and Karayücel, 2006). This destructive effect has started in the mid 1990s because the observations verified that *C. gallina* population was still vital until 1995 in the South eastern Black Sea (Zengin, 2003). In surveys planned to estimate the amount of bycatch in the Rapa whelk commercial catches, the percent of empty shells was recorded to be 73% and 85% for *Anadara cornea* and *Chamelea gallina,* respectively (Knudsen and Zengin, 2006). Recently, the Rapa whelk started to threaten some other mollusc and crustacean communities *(L. depurator,* Donax sp., Isopods, Amphipods and Decapods).



	1986	1991	1995	1999	2003
Avarage length	110	67,2	65	54,3	45,1
Biomass		1,98	10,1	6,4	14,2

Fig. 4.7.3.5. Relationship between the mean length and biomass of the Rapa whelk in south eastern Black Sea.

Some biological parameters have been estimated during the study carried out on eastern Rapa whelk population along Trabzon coasts (Emiral, 2003). The measured lengths have ranged between 2.0-9.5 cm, with mean length of 5.3 cm. The shell width is calculated as 3.7 cm and the mean weight as 27.7 g. The length-weight relationship is determined as $W=0.9x10^{-3}L^{3.1459.}$ According to Bhattacharya method, age classes ranged between 0 and 5 years, while growth parameters were estimated as L_∞ = 103.97 mm, k = 0.345, t_0 = -0.310 and W_∞ = 213.52 g. and the sex ratio is 1:1.6 (female:male). The first maturity length is 4.0 cm. Spawning occurs between June and August (Fig. 4.7.3.6).

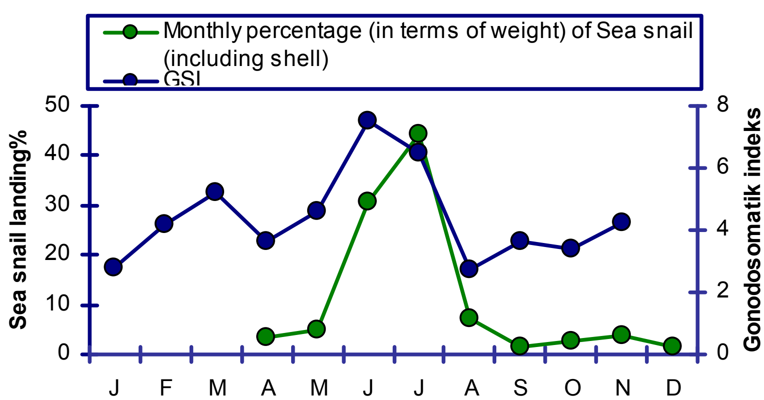


Fig. 4.7.3.6. Relationship between the monthly landings and the reproduction period of Rapa whelk.

4.7.4 Management measures

In Turkey, National Fisheries Agency (MARA) has implemented limitations to the Rapa whelk fishery. The fishing method allowed in the western part is scuba diving, while dredges (mesh size as minimum 40 mm) are permitted in eastern part. Scuba diving is allowed throughout all year but dredges are banned between 1 May and 30 August. In addition, fishing at night is also banned. The area up to 500 m from the coast is closed to fishing. These limitations are however not thoroughly respected and illegal fishing is increasing throughout the years. The possible incentives for illegal fisheries may be considered as:

1. The Rapa whelk migrates to the coastal zone (5-15 m depths) to reproduce in summer and the illegal fishing increases especially in this period due to abundance and the gear efficiency resulting in higher catches. The Rapa whelk population moves to deeper waters in autumn when the temperature decreases and the decrease of the catch rates in this legal period compels the fishermen to illegal activities (Fig. 4.7.4.1).
2. The meat yield reaches its highest percent in summer and landing prices are higher. In the legal period (autumn) the condition of Rapa whelk declines, so the meat yield and the industry is unwilling to pay good prices (Fig. 4.7.4.1).
3. In the legal period the artisanal fishers who catch Rapa whelk switch to bonito fishing which is more profitable.
4. Except the banned period some of the small scale fishers work as a crew in large vessels (trawlers and purse seiners) and already have a job. By the closure of the fishing season for large vessels, they start fishing illegally Rapa whelk.

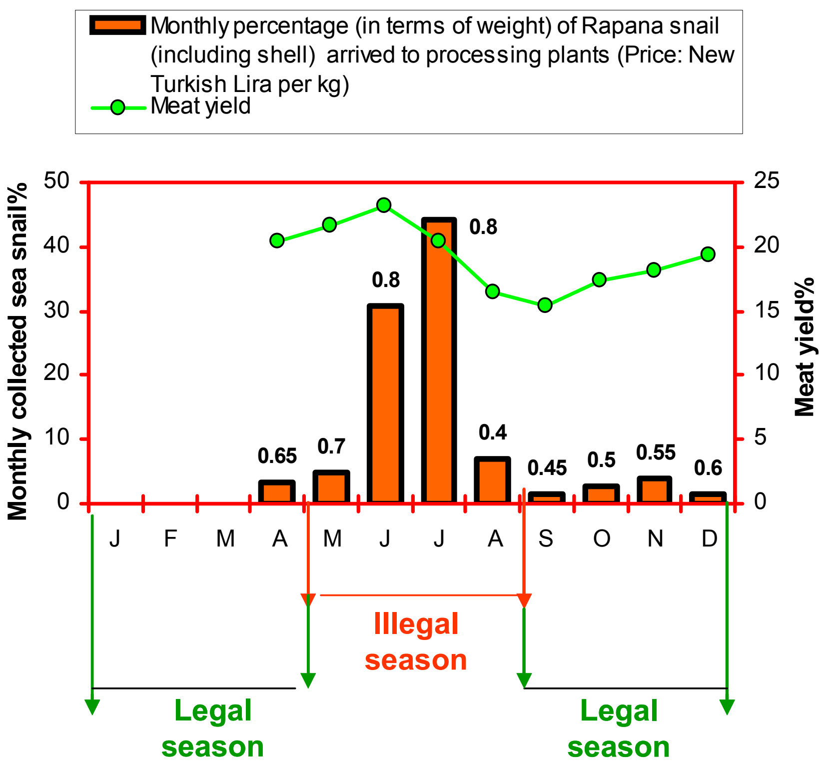


Fig. 4.7.4.1. The diagram of the relations between fishing season, landing, meat yield and price for Turkey.

In Bulgaria, fisheries on Rapa whelk is permitted only by Scuba diving for which a license system is in force. In Ukraine, an annual limit for Rapa whelk harvests up to 400 t has been introduced since 2002.

4.7.5 Availability of Data for assessment

Compilation of input data for catch-at-age and/or catch-at-length historical stock assessment of Rapa whelk may be difficult due to several reasons such as:
- the number and location of different stocks of Rapa whelk within the Black Sea area is still unclear;
- only fragmentary data on size and age composition Rapa whelk exist;
- a high proportion of the catches are unreported (illegal).

An opinion about the feasibility of quantitative stock assessment and the choice of specific methods can be made, after the compilation and analysis of all available data from fisheries, surveys and other investigations undertaken in the Black Sea area (Table 4.7.5.1).

Table 4.7.5.1. Data availability for Rapa welk by countries.

Type of data	**BG**	**RO**	**RF**	**TR**	**UKR**
Official landings	1994 - 2009		1988-2009	1988-2009	1988-2009
Illegal, Unreported Catch	Yes, could be estimated by export data		No	may be estimated for 2000-2009	No
Fishing effort and CPUE	No			2000-2009	1989-2009
Number of fishing vessels	No, only number of licensees for divers		No	2000-2009	No
Research surveys	Yes (1993 - published, 1996, 2006, 2010 - unpublished)			1991, 1999-2000, 2003-2008	1989-1993, 1998
Length composition	1993, 1996, 2006 and 2010			1991, 1999-2000	1988-2009
Weight at length (survey, landings)	1993, 1996, 2006 and 2010			1991, 2003,?	1988-2009
Age composition	only for 1993, 2010			By length frequency	1988-2009
Weight at age (survey, landings)	only for 1993, 2010			?	1988-2009
Maturity at age	No			?	1989-1993, 1998
Natural mortality	only for 1993, 2010			2003	1989

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6 APPENDIX I SGRST-10-03 PART B LIST OF PARTICIPANTS

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7 APPENDIX II EXPERT DECLARATIONS

Declarations of invited experts are published on the STECF web site on https://stecf.jrc.ec.europa.eu/home together with the final report.

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The STECF provides its scientific advice for 2011 Part 3b (Black Sea) as drafted by the STECF-SGRST 10-03 Working Group held in Cádiz, Spain from 11-15 October 2010. Scientific advice for the fisheries of turbot and sprat in the Black Sea for 2011 under different management options is provided. The Report was reviewed by the STECF at its 35th plenary session held in Brussels from 8-12 November 2010.

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